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USAAVLABS TECHNICAL REPORT 70-74D
STABILITY AND CONTROL OF HELICOPTERS IN STEEP APPROACHES

VOLUME IV
DERIVATIVES AND TRANSFER FUNCTIONS FOR THE AH-56A COMPOUND HELICOPTER, AND DATA ON LOW-ALTITUDE TURBULENCE REPRESENTATION

By
Julian Wolkovitch
John A. Hoffman
May 1971

EUSTIS DIRECTORATE
U. S. ARMY AIR MOBILITY RESEARCH AND DEVELOPMENT LABORATORY
FORT EUSTIS, VIRGINIA

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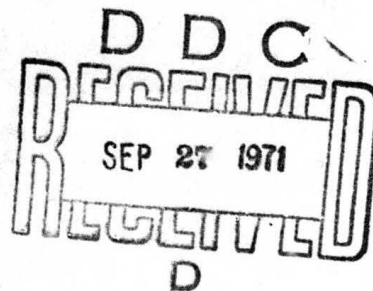
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U. S. ARMY AIR MOBILITY RESEARCH & DEVELOPMENT LABORATORY
EUSTIS DIRECTORATE
FORT EUSTIS, VIRGINIA 23604

The report has been reviewed by the Eustis Directorate,
U. S. Army Air Mobility Research and Development Labora-
tory, and is judged to be technically sound.

The primary effort is to examine the behavior of rotary-
wing aircraft in steep approaches, from the standpoint
of aerodynamics and dynamics, and the resultant effects
on human and automatic control.

The report is presented in four volumes. Volume I sum-
marizes the main results of the study. Volume II des-
cribes the MOSTAB program. Volume III presents derivatives
and transfer functions for the YHC-1A tandem-rotor heli-
copter and the S-58 single-rotor helicopter. Volume IV
presents derivatives and transfer functions for the AH-56A
compound helicopter and data on low-altitude turbulence
representation.

The program was conducted under the technical management
of Mr William D. Vann, Aeromechanics Division.

DISCLAIMERS

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

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STABILITY AND CONTROL OF HELICOPTERS IN
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VOLUME IV

DERIVATIVES AND TRANSFER FUNCTIONS FOR THE AH-56A COMPOUND HELICOPTER,
AND DATA ON LOW-ALTITUDE TURBULENCE REPRESENTATION

MRI REPORT NO. 2284-1

By

Julian Wolkovitch
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Prepared by

Mechanics Research, Inc.
Los Angeles, California

for

EUSTIS DIRECTORATE
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FORT EUSTIS, VIRGINIA

ABSTRACT

Derivatives and transfer functions are presented for the Lockheed AH-56A helicopter. The flight conditions considered include airspeeds of from 0 to 100 knots and descent rates from 0 to 28.8 fps. A critical review is given of published data on low-altitude turbulence.

4. KEY WORDS	LINK A		LINK B		LINK C	
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HELICOPTER AERODYNAMICS						
HELICOPTER STABILITY DERIVATIVES						
HELICOPTER TRANSFER FUNCTIONS						
V/STOL STEEP APPROACH						
VORTEX-RING STATE						
SIKORSKY S-58 STABILITY AND CONTROL						
LOCKHEED AH-56A STABILITY AND CONTROL						
BOEING-VERTOL YHC-1A STABILITY AND CONTROL						
MOSTAB DIGITAL COMPUTER PROGRAM						

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13. ABSTRACT

Derivatives and transfer functions are presented for the Lockheed AH-56A helicopter. The flight conditions considered include airspeeds of from 0 to 100 knots and descent rates from 0 to 28.8 fps. A critical review is given of data on low altitude turbulence.

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NOTICE TO USERS

FOREWORD

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LIST OF SYMBOLS

A	Constant relating σ_w and V
A_{1s}	Lateral cyclic pitch, radians
B_{1s}	Longitudinal cyclic pitch, radians
C	Constant relating σ_u and U*
C_p	Specific heat coefficient, BTU's/°F-lb
f	Reduced frequency = nZ/V cycles
g	Gravitational constant, ft/sec^2
h^1	Function relating σ_w and V
H	Heat flux, $BTU's/ft^2$-sec
k	Von Karman constant
K_h	Eddy conductivity $-H/C_p\rho \frac{\partial\theta}{\partial Z}$, ft^2/sec
K_m	Eddy viscosity $U*^2 / \frac{\partial V}{\partial Z}$, ft^2/sec
L	Scaling length, ft
L	Rolling moment or acceleration, as appropriate
L^1	$= LK_h/K_m$, ft
M	Pitching moment or acceleration, as appropriate
n	Frequency, cycles per second
N	Yawing moment or acceleration, as appropriate
p	Exponent in wind speed-altitude relationship
P	Roll rate

Q	Pitch rate
R	Yaw rate
R_f	Flux Richardson number-ratio of shear energy to buoyant energy
R_1	Gradient Richardson number $\dfrac{g}{\theta}\ \dfrac{\partial\theta}{\partial Z}\ /\ \left(\dfrac{\partial U}{\partial r_3}\right)^2$
r_3	Vertical coordinate of distance vector, ft
S	Spectral density
T	Temperature, °F
T*	Scaling temperature $-H/kU*C_p\rho$, °F
T_e	Trimmed iteration column vector
U	Trimmed velocity along x-axis
U*	Friction velocity, $\sqrt{\tau/\rho}$, ft/sec
U, V	Mean wind amplitude, ft/sec
u	Perturbation velocity along x-axis
V	Trimmed velocity along y-axis
v	Perturbation velocity along y-axis
W	Trimmed velocity along z-axis
w	Perturbation velocity along z-axis
x	x-axis force or acceleration, as appropriate
y	y-axis froce or acceleration, as appropriate
z	z-axis force or acceleration, as appropriate

Z	Elevation, ft
Z_o	Roughness length, ft
β	Constant relating V and Z
β^1	$= \beta K_h / K_m$
θ	Potential temperature of air, °F
θ_o	Potential temperature at Z_o, °F
θ_{op}	Pusher propeller collective pitch, radian
θ_{otr}	Tail rotor collective pitch, radians
ρ	Density of air, lb/ft^3
σ	Standard deviation
τ	Horizontal surface stress, lb/ft^2
Φ	Bank angle, radians
θ	Pitch angle, radians
ψ	Function relating V and Z

Special Subscripts

u	Subscript for longitudinal wind direction
v	Subscript for lateral wind direction
w	Subscript for lateral wind direction

x

VII. LOCKHEED AH-56A DERIVATIVES AND TRANSFER FUNCTIONS

INTRODUCTION

For brevity, this section describes only those features of the AH-56A derivative and transfer function print-out which differ from the corresponding printouts for the S-58 given in Part VI. It is therefore essential for the reader to at least skim through Part VI before reading further.

Derivatives, residues, eigenvectors, and transfer functions were calculated for the AH-56A in the flight conditions indicated below. As with the S-58, V_{TAS} is the total airspeed, not the horizontal component.

TABLE I	AH-56A FLIGHT CONDITIONS; SPEED AND DESCENT RATE				
V_{TAS} Knots	0	20	40	60	100
Rate of	9.6	9.6	9.6	9.6	9.6
Descent	19.2	19.2	19.2	19.2	19.2
fps	28.8	28.8	28.8	28.8	28.8

TABLE II	AH-56A FLIGHT CONDITIONS; SPEED AND DESCENT ANGLE				
V_{TAS} Knots	0	20	40	60	100
Descent	-90	-16.5	-8.05	-5.41	-3.25
Angle	-90	-33.5	-16.5	-10.9	-6.52
Degrees	-90	-58.3	-25.1	-16.6	-9.81

This Part presents derivatives for all the above flight conditions. In addition, the 28.8-fps vertical descent case and the 40-knot case at the same descent rate ($\gamma = -25.1$ degrees) were re-run without the cyclic variation of tip losses. Space limitations precluded a full presentation of all the transfer functions, residues, and eigenvectors for all of these cases. Therefore, only the following data are presented here.

(1) Derivatives for all the above flight conditions

(2) Transfer function numerators relating u, v, w, p, q, and r (measured in stability axes) to all control inputs for speeds of 0, 20, 40, 60, and 100 knots in level flight and at 28.8 fps rate of descent. The control inputs include longitudinal and lateral cyclic pitch, main rotor collective pitch, tail rotor collective pitch, and collective pitch of the pusher propeller.

(3) Eigenvalues (transfer function denominator roots) for the above flight conditions. Eigenvalues for the remaining flight condition. are included in Chapter VIII, Table XXII, which compares all the eigenvalues.

Residues and eigenvectors of particular significance are given in Chapter VIII, but none are included in this Part, although all the residues were calculated at each flight condition.

Explanation of the Print-Out Format

The print-out format is identical to that of Part VII with the following exception:

The controls are denoted as follows:

$C(1) = \theta_o$ = main rotor collective pitch, radians

$C(2) = B_{1s}$ = longitudinal cyclic pitch, radians

$C(3) = A_{1s}$ = lateral cyclic pitch, radians

$C(4) = \theta_{otr}$ = tail rotor collective pitch, radians

$C(5) = \theta_{op}$ = pusher propeller collective pitch, radians

The trimmed iteration column vector, as for the S-58, contains $C(1)$, $C(2)$, $C(3)$, $C(4)$, Θ, and Φ in that order.

Note that the comment of Part VI regarding the root-locus gains also applies to the AH-56A data of this Part.

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LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 1 SPEED= 67.8 FT/SEC. H-DOT=-28.8 FT/SEC. GAMMA=-25.1 DEG.
GROSS WEIGHT=15600. SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.1169+03	.1309+01	-.7964+02	-.1307+03	.1745+04	.3392+03
Y	-.1465+01	-.3566+02	-.1032+01	-.1392+04	-.1243+03	.3392+03
Z	-.1610+03	-.1139+01	-.1824+03	.7995+02	-.6143+03	.1372+04
L	-.1420+03	-.4584+02	-.9569+02	-.7471+05	.9128+04	.6523+03
M	.1676+03	-.3230+02	-.8663+02	-.7067+04	-.8791+05	.2501+05
N	-.1962+03	.5116+03	-.2264+03	.2466+05	-.2201+04	-.3236+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.4000-01	.2279-03	-.8829-01	-.2404+02	.2321+01	.1096+02
Y	.2108-01	.6738-04	.4606-01	-.1896+01	-.3018+02	.8645-00
Z	.2604-01	.4635-03	.5536-01	.1367+02	-.1562-00	-.6225+01
L	.2723+01	.2199-02	.5967+01	.2448+04	-.1228+04	-.1113+04
M	.1695+01	.1010-02	.3695+01	.1250+04	-.2986+04	-.5699+03
N	-.1354+01	-.1592-02	-.2965+01	-.1198+04	.5821+03	.5551+03

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.5069+05	-.5488+04	.1995+05	-.9903+02	-.8801+04
Y	-.1533+04	.1459+05	.6296+04	.6863+04	.1455-02
Z	-.1074+06	.3158+04	.9953+04	.1088+02	.4171+04
L	-.9136+04	.5989+06	.2532+06	-.8069+05	-.4287+04
M	.1839+06	.2724+06	-.6766+06	-.1345+04	.1301+05
N	.6210+05	-.2901+06	-.9290+05	-.1918+06	-.9397+03

THE INERTIA TENSOR

$$
\begin{array}{ccc}
.1899+05 & -.1278-05 & .1642+05 \\
-.1278-05 & .5000+05 & .6769-06 \\
.1642+05 & .6769-06 & .4751+05
\end{array}
$$

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.6169+02	-.2794-08	.2814+02	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.1295-00 -.1217-02 .1142-01 .1607-01 -.1077-01 -.4171-02

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.4387-00   PHI -.4607-02
AIRCRAFT INERTIAL SPEED= .6780+02

3

DENOMINATOR CHARACTERISTIC
ROOTS

REAL PART	IMAGINARY PART
-.6279-01	.0000
-.9903+01	.0000
-.1894+01	.0000
-.4087-01	.2621-00
-.4087-01	-.2621-00
-.2328-00	.7577-00
-.2328-00	-.7577-00
-.5257-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000
.0000	.0000

NUMERATORS
(NOTE- NUMERATOR ROOTS LESS THAN 1.0E-7 TIMES THE
LARGEST NUMERATOR ROOT ARE NOT INCLUDED IN THE BODF GAIN).

X(1)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .1043+03

BODE GAIN = -.1031+04

ROOTS

REAL PART	IMAGINARY PART
-.3151-07	.0000
-.9925+01	.0000
-.2481-00	.8153-00
-.2481-00	-.8153-00
-.4914-00	.6966-00
-.4914-00	-.6966-00
-.7523-00	.0000
-.6864-01	.0000
.0000	.0000
.0000	.0000

4

X(2)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .3403+01

BODE GAIN = .5134+02

ROOTS

REAL PART	IMAGINARY PART
.8965-02	.0000
-.5841+02	.0000
-.7281-00	.0000
-.6550-01	.3195-00

REAL PART	IMAGINARY PART
-.6550-01	-.3195-00
-.2621+01	.1821+01
-.2621+01	-.1821+01
.0000	.0000
-.3801-08	.0000
.0000	.0000

X(3)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .2219+03

BODE GAIN = .4364+03

ROOTS

REAL PART	IMAGINARY PART
-.9540-01	.0000
-.9972+01	.0000
-.2131-00	.0000
-.2300-00	.7472-00
-.2300-00	-.7472-00
-.9535-00	.0000
.4454-00	.0000
-.1735-07	.0000
.0000	.0000
.0000	.0000

5

X(4)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .3979+01

BODE GAIN = .1587-04

ROOTS

REAL PART	IMAGINARY PART
.3666-05	.0000
-.1288+01	.0000
-.6900-00	.0000
-.2692-00	.1593-00
-.2692-00	-.1593-00
.2260+01	.0000
-.6182-01	.3844-00
-.6182-01	-.3844-0C
.0000	.0000
.0000	.0000

X(5)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.3750+01

BODE GAIN = -.4252-01

ROOTS

REAL PART	IMAGINARY PART
.1342-01	.0000
-.1062+02	.0000
-.2452-00	.7604-00
-.2452-00	-.7604-00
-.5212-00	.0000
-.7422-01	.3231-01
-.7422-01	-.3231-01
.0000	.0000
.1341-06	.0000
-.5402-07	.0000

6

X(6)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.2879+01

BODE GAIN = .7001-05

ROOTS

REAL PART	IMAGINARY PART
.7585-06	.0000
-.1190+00	.2957-00
-.1190+00	-.2957-00
.5699-01	.3391-00
.5699-01	-.3391-00
-.2290+01	.2200+01
-.2290+01	-.2200+01
-.7243-00	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .1548+02

BODE GAIN = -.1284+04

ROOTS

REAL PART	IMAGINARY PART
-.2089-06	.0000
-.3325-00	.0000
-.1013+00	.0000
-.1829-00	.7536-00
-.1829-00	-.7536-00
-.8066+01	.0000
-.1035+01	.3581+01
-.1035+01	-.3581+01
.0000	.0000
.0000	.0000

7

X(2)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.2928+02

BODE GAIN = .2788+04

ROOTS

REAL PART	IMAGINARY PART
-.2403-01	.2522-00
-.2403-01	-.2522-00
-.2526-00	.0000
-.7362+02	.0000
-.2180+01	.0000
-.8386-00	.5461-00
-.8386-00	-.5461-00
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.8901+01

BODE GAIN = .1433+04

ROOTS

REAL PART	IMAGINARY PART
-.1210+00	.0000
-.6055+02	.0000
-.5525+01	.0000
-.1952-00	.7688-00
-.1952-00	-.7688-00
-.2084-00	.3600-00
-.2084-00	-.3600-00
.0000	.0000
.0000	.0000
.0000	.0000

8

X(4)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.6982+02

BODE GAIN = .2402+02

ROOTS

REAL PART	IMAGINARY PART
-.4563-01	.2755-00
-.4563-01	-.2755-00
-.2118-00	.0000
-.5418-00	.0000
-.1942+01	.0000
-.1110+00	.7278-00
-.1110+00	-.7278-00
.0000	.0000
.0000	.0000
.0000	.0000

X(5)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.8042+01

BODE GAIN = -.2358-00

ROOTS

REAL PART	IMAGINARY PART
.3765-01	.0000
-.9270-01	.5926-01
-.9270-01	-.5926-01
-.5384+01	.0000
-.2016-00	.7549-00
-.2016-00	-.7549-00
-.5359-00	.0000
-.1118-07	.0000
.0000	.0000
-.7451-08	.0000

9

X(6)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .3227+02

BODE GAIN = .1176-04

ROOTS

REAL PART	IMAGINARY PART
.2297-06	.0000
-.2077+01	.0000
-.5749-00	.8193-00
-.5749-00	-.8193-00
-.4092-01	.2692-00
-.4092-01	-.2692-00
.6603-00	.0000
-.4262-00	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3927+02

BODE GAIN = .2684+04

ROOTS

REAL PART	IMAGINARY PART
-.7622-07	.0000
-.3300-00	.0000
-.6035-01	.0000
-.1020+02	.0000
-.1901-00	.3879+01
-.1901-00	-.3879+01
-.2335-00	.7461-00
-.2335-00	-.7461-00
.0000	.0000
.5859-07	.0000

10

X(2)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.1369+02

BODE GAIN = .4674+03

ROOTS

REAL PART	IMAGINARY PART
.3532-08	.0000
-.6856+02	.0000
-.4872-01	.1017+00
-.4872-01	-.1017+00

.1753-00	.4451-00
.1753-00	-.4451-00
-.1773+01	.1242+01
-.1773+01	-.1242+01
.0000	.0000
.0000	.0000

X(3)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.2160+02

BODE GAIN = -.2482+04

ROOTS

REAL PART	IMAGINARY PART
-.5917-01	.0000
.4217+02	.0000
-.2300-00	.7480-00
-.2300-00	-.7480-00
-.1075+02	.0000
-.2166-00	.3803-00
-.2166-00	-.3803-00
-.1482-09	.0000
.0000	.0000
.0000	.0000

X(4)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3087+02

BODE GAIN = .4101+01

ROOTS

REAL PART	IMAGINARY PART
.5423-02	.1539-00
.5423-02	-.1539-00
-.3281-00	.4163-01
-.3281-00	-.4163-01
-.8947-01	.9575-00
-.8947-01	-.9575-00
-.1516+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(5)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .1340+02

BODE GAIN = -.4027-01

ROOTS

REAL PART	IMAGINARY PART
-.1334-01	.0000
-.2171-01	.0000
-.1121+02	.0000
-.2336-00	.7504-00
-.2336-00	-.7504-00
-.5362-00	.0000
-.7655-01	.0000
.1718-06	.0000
-.4040-09	.0000
.0000	.0000

12

X(6)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .1373+02

BODE GAIN = .6741+01

ROOTS

REAL PART	IMAGINARY PART
-.1432-02	.1610-00
-.1432-02	-.1610-00
-.1309-00	.4115-00
-.1309-00	-.4115-00
-.1418+01	.1229+01
-.1418+01	-.1229+01
.1023+01	.0000
-.1863-08	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .2440-00

BODE GAIN = .9822+02

ROOTS

REAL PART	IMAGINARY PART
-.1153-06	.0000
-.9699+01	.3368+01
-.9699+01	-.3368+01
-.2666+01	.0000
-.2807-00	.0000
.1938+01	.0000
-.1286-00	.2356-00
-.1286-00	-.2356-00
.4657-09	.0000
.0000	.0000

13

X(2)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.1416+02

BODE GAIN = .2053+02

ROOTS

REAL PART	IMAGINARY PART
-.3279-02	.0000
-.1894+02	.0000
-.8761+01	.0000
-.1887+01	.0000
-.5451-00	.0000
-.4128-01	.2630-00
-.4128-01	-.2630-00
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.4491-01

BODE GAIN = -.1263+03

ROOTS

REAL PART	IMAGINARY PART
-.2197-07	.0000
.1357+03	.0000
-.1904-00	.4257-00
-.1904-00	-.4257-00
-.1049+00	.2335-00
-.1049+00	-.2335-00
-.1381+02	.0000
-.2483+01	.0000
.0000	.0000
.0000	.0000

X(4)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .9095-00

BODE GAIN = -.3884+01

ROOTS

REAL PART	IMAGINARY PART
-.4112-01	.2642-00
-.4112-01	-.2642-00
-.2441-00	.1837-00
-.2441-00	-.1837-00
-.1711+02	.0000
-.1905+01	.0000
-.5369-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(5)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .7414-02

BODE GAIN = .3813-01

ROOTS

REAL PART	IMAGINARY PART
.8734-08	.0000
-.8473+02	.0000
.3656+01	.0000
-.5503-00	.0000
-.1274-00	.2112-00
-.1274-00	-.2112-00
-.1783-00	.0000
.7218-01	.0000
.8568-07	.0000
.0000	.0000

15

X(6)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN=   .3744+01

BODE GAIN = -.8277+01

ROOTS

REAL PART	IMAGINARY PART
-.4374-01	.2642-00
-.4374-01	-.2642-00
-.7661-02	.2997-00
-.7661-02	-.2997-00
-.9143+01	.0000
-.1886+01	.0000

-.5450-00	.0000
.7477-10	.0000
-.5891-08	.0000
.0000	.0000

X(1)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   .1814+02

BODE GAIN = -.5021+02

ROOTS

REAL PART	IMAGINARY PART
.6527-07	.0000
-.9916+01	.0000
-.1736-00	.0000
-.5800-01	.0000
-.1057+01	.3124-00
-.1057+01	-.3124-00
-.2355-00	.7542-00
-.2355-00	-.7542-00
.0000	.0000
.0000	.0000

16

X(2)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .1443-01

BODE GAIN = -.2710+01

ROOTS

REAL PART	IMAGINARY PART
.1791-06	.0000
-.5848+03	.0000
-.1143+01	.1119+01
-.1143+01	-.1119+01

.4429-01	.0000
.1649+01	.0000
.3395-00	.0000
.1387-00	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.8595+01

BODE GAIN = .4826+02

ROOTS

REAL PART	IMAGINARY PART
-.5703-01	.0000
-.9596+01	.0000
-.4776+01	.0000
-.2299-00	.7564-00
-.2299-00	-.7564-00
-.2210-00	.2128-00
-.2210-00	-.2128-00
.0000	.0000
.0000	.0000
.0000	.0000

17

X(4)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .4331-00

BODE GAIN = -.7678-01

ROOTS

REAL PART	IMAGINARY PART
-.7591-07	.0000
-.3223-00	.1083+00
-.3223-00	-.1083+00
.1312-00	.1089+00
.1312-00	-.1089+00
-.2711-00	.1015+01
-.2711-00	-.1015+01
-.1308+01	.0000
.0000	.0000
.0000	.0000

X(5)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.2635-00

BODE GAIN = .7536-03

ROOTS

REAL PART	IMAGINARY PART
.1449-02	.0000
-.1082+02	.0000
-.2299-00	.7535-00
-.2299-00	-.7535-00
-.5328-00	.0000
.2329-00	.0000
-.6488-01	.0000
-.1441-08	.0000
.2184-06	.0000
.3592-07	.0000

18

X(6)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.1457-00

BODE GAIN = -.1636-00

ROOTS

REAL PART	IMAGINARY PART
.1374-00	.1124+00
.1374-00	-.1124+00
-.7308-01	.4040-00
-.7308-01	-.4040-00
.2997+01	.0000
-.9940-00	.9713-00
-.9940-00	-.9713-00
.0000	.0000
.0000	.0000
.0000	.0000

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 2   SPEED= 28.8 FT/SEC. H-DOT=-28.8 FT/SEC.   GAMMA=-90.0 DEG.
GROSS WEIGHT=15600. SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.7513+02	.9704+01	-.5058+01	.1011+04	-.6809+02	-.1705+03
Y	.2825+01	-.2100+02	.2974+01	.4360+03	-.1948+03	.1632+04
Z	-.2626+01	-.2556+01	-.8706+01	.8236+02	-.1664+04	-.4034+03
L	-.2280+03	.3516+03	-.3561+02	-.1227+05	-.4563+04	-.1849+04
M	-.1201+03	-.5593+02	-.5100+03	.5707+04	-.8952+05	.1075+05
N	-.2371+02	.3998+03	-.8163+02	-.1258+04	-.1159+05	-.8650+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.1073-03	.2261-04	.4161-05	.3059-01	.4676-00	.9090-01
Y	-.1038-01	-.3476-03	-.5900-04	.1279+01	-.2587+02	-.4791-00
Z	.1663-01	-.1415-03	-.2919-03	-.4234-00	.5322-00	-.2588+02
L	.3891-03	.5335-02	.2727-02	.1549+02	-.1137+03	.1382+03
M	.1163+00	.6497-02	-.1977-02	-.1668+03	.2938+04	-.1425+04
N	.1182+00	.3169-02	-.2009-03	-.1804+02	.1430+04	.2952+04

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.1128+06	-.5360+03	-.1971+03	-.5756+03	.1232+03
Y	-.5595+04	.1826+05	.5659+04	.8039+04	.4163+01
Z	.4081+03	.5621+04	-.1831+05	.1237+02	.5086+04
L	.2347+06	-.2937+05	.2556+05	-.2429+06	-.2594+04
M	-.7536+04	.2740+06	-.6723+06	-.2167+05	.5528+04
N	-.5486+04	-.6730+06	-.2749+06	-.3850+04	.1192+03

THE INERTIA TENSOR

.5497+05	.2437+03	-.7611+03
.2437+03	.5001+05	-.3728+02
-.7611+03	-.3728+02	.1151+05

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
-.5040-00	-.1409+01	.2876+02	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.2135-00	.8854-03	-.7529-02	.1343-00	.1750-01	-.4895-01

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= .1572+01   PHI .0000
AIRCRAFT INERTIAL SPEED= .2880+02

20

DENOMINATOR CHARACTERISTIC
ROOTS

REAL PART	IMAGINARY PART
-.8006-01	.3619-00
-.8006-01	-.3619-00
-.3925-01	.4387-00
-.3925-01	-.4387-00
-.1805-00	.9069-01
-.1805-00	-.9069-01
-.9824+01	.0000
-.1905+01	.0000
.1490-07	.0000
.0000	.0000
.0000	.0000
.0000	.0000

NUMERATORS
(NOTE- NUMERATOR ROOTS LESS THAN 1.0E-7 TIMES THE
LARGEST NUMERATOR ROOT ARE NOT INCLUDED IN THE BODE GAIN).

X(1)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .2328+03

BODE GAIN =   -.9600+03

ROOTS

REAL PART	IMAGINARY PART
-.1659-00	.0000
-.9823+01	.0000
-.1905+01	.0000
-.3698-01	.4405-00
-.3698-01	-.4405-00
-.8356-01	.3624-00
-.8356-01	-.3624-00
.0000	.0000
.0000	.0000
.0000	.0000

X(2)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .1152+02

BODE GAIN =   .2197+03

ROOTS

REAL PART	IMAGINARY PART
.7696-06	.0000
-.9177+01	.0000
-.2010+01	.000C
-.3622-00	.1236+00

-.3622-00	-.1236+00
-.8173-01	.4515-00
-.8173-01	-.4515-00
.6822-00	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   -.8468-00

BODE GAIN =   .6502+03

ROOTS

REAL PART	IMAGINARY PART
-.7557-01	.3741-00
-.7557-01	-.3741-00
-.2597-00	.0000
-.1233+01	.0000
-.1022+02	.0000
.1342+01	.5565+01
.1342+01	-.5565+01
.0000	.0000
.0000	.0000
.0000	.0000

22

X(4)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.4267+01

BODE GAIN = .4138+02

ROOTS

REAL PART	IMAGINARY PART
-.7722-01	.3851-00
-.7722-01	-.3851-00
-.2714-01	.4302-00
-.2714-01	-.4302-00
-.9839+01	.0000
-.1918+01	.0000
-.3648-00	.0000
-.4478-06	.0000
-.2611-08	.0000
.3725-08	.0000

X(5)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .1889-00

BODE GAIN = .1040-03

ROOTS

REAL PART	IMAGINARY PART
.1876-03	.2281-02
.1876-03	-.2281-02
-.1042+02	.0000
-.2585-00	.0000
.5460+01	.0000
-.7498-01	.3741-00
-.7498-01	-.3741-00
.1132-06	.0000
-.3992-08	.0000
.9779-08	.0000

23

X(6)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .3062-00

BODE GAIN = -.6456-04

ROOTS

REAL PART	IMAGINARY PART
.1432-03	.0000
-.9392-00	.2705+01
-.9392-00	-.2705+01
-.8576-01	.4519-00
-.8576-01	-.4519-00
-.3684-00	.0000
.4689-01	.0000
-.8149-08	.0000
.5588-08	.0000
-.6802-08	.0000

X(1)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .1113+01

BODE GAIN = .7291+03

ROOTS

REAL PART	IMAGINARY PART
-.4130-01	.4320-00
-.4130-01	-.4320-00
-.6524-00	.0000
.1326+02	.0000
-.1075+01	.1729+01
-.1075+01	-.1729+01
-.1973+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

24

X(2)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.3733+02

BODE GAIN = .1968+04

ROOTS

REAL PART	IMAGINARY PART
-.1900-00	.8143-01
-.1900-00	-.8143-01
-.6145+02	.0000
-.1943+01	.0000
-.1099+01	.0000
-.3808-01	.4356-00
-.3808-01	-.4356-00
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.1575+02

BODE GAIN = .5833+03

ROOTS

REAL PART	IMAGINARY PART
-.1257-00	.0000
-.2184+02	.0000
-.3480+01	.0000
-.1076+01	.0000
.1490-01	.4510-00
.1490-01	-.4510-00
-.3602-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(4)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN=   .1654+01

BODE GAIN =   .3875+02

ROOTS

REAL PART	IMAGINARY PART
-.1411-00	.0000
-.2642+01	.3357-00
-.2642+01	-.3357-00
-.9161-00	.0000
.2430+01	.0000
-.3842-01	.4352-00
-.3842-01	-.4352-00
-.1315-06	.0000
.6977-09	.0000
.0000	.0000

X(5)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN=   -.8119+01

BODE GAIN =   .9711-04

ROOTS

REAL PART	IMAGINARY PART
-.4933-03	.0000
-.4944+01	.0000
.1444-01	.4555-00
.1444-01	-.4555-00
-.3525-00	.0000
-.1214+00	.0000
-.1123-01	.0000
.6634-07	.0000
.3551-08	.0000
.1164-08	.0000

26

X(6)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN=   .7741+02

BODE GAIN =   -.6054-04

ROOTS

REAL PART	IMAGINARY PART
-.5056-03	.0000
-.1970+01	.0000
-.3806-01	.4359-00
-.3806-01	-.4359-00
-.1985-00	.7020-01
-.1985-00	-.7020-01
-.1682-02	.0000
.4700-08	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN=   .4261-00

BODE GAIN =   .3305+03

ROOTS

REAL PART	IMAGINARY PART
.1316-05	.0000
.2685+02	.0000
-.3440-01	.3778-00
-.3440-01	-.3778-00
-.6037-00	.3595-00
-.6037-00	-.3595-00
-.2686+01	.6959-00
-.2686+01	-.6959-00
.0000	.0000
.0000	.0000

27

X(2)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.1242+02

BODE GAIN = .4852+03

ROOTS

REAL PART	IMAGINARY PART
.3213-06	.0000
-.8022+02	.0000
-.1578+01	.0000
-.8716-00	.0000

-.1967-00	.7347-01
-.1967-00	-.7347-01
.5821-02	.4042-00
.5821-02	-.4042-00
.0000	.0000
.0000	.0000

X(3)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .3597+02

BODE GAIN = -.1297+04

ROOTS

REAL PART	IMAGINARY PART
-.9549-01	.3574-00
-.9549-01	-.3574-00
-.1680-00	.1078+00
-.1680-00	-.1078+00
-.9855+01	.4086+01
-.9855+01	-.4086+01
-.1182+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

28

X(4)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN=   .1150-01

BODE GAIN =   .1361+02

ROOTS

REAL PART	IMAGINARY PART
-.1314-00	.0000
.7179+03	.0000
-.3865-00	.6296-00
-.3865-00	-.6296-00
-.3014+01	.0000
-.7549-02	.3939-00
-.7549-02	-.3939-00
-.5960-07	.0000
.0000	.0000
.0000	.0000

X(5)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN=   .1327+02

BODE GAIN =   .3548-04

ROOTS

REAL PART	IMAGINARY PART
.1201-07	.0000
.3858-06	.0000
-.1130+02	.0000
-.9573-01	.3583-00
-.9573-01	-.3583-00
-.1687-00	.1065+00
-.1687-00	-.1065+00
.1279-01	.0000
-.6880-04	.0000
-.4657-09	.0000

29

X(6)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .3440+02

BODE GAIN = -.2127-04

ROOTS

REAL PART	IMAGINARY PART
-.2268-03	.0000
-.1199+01	.0000
-.2117-00	.4451-01
-.2117-00	-.4451-01
.5897-02	.4089-00
.5897-02	-.4089-00
-.5916-02	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .1189+01

BODE GAIN = -.2437+03

ROOTS

REAL PART	IMAGINARY PART
-.7443-01	.3883-00
-.7443-01	-.3883-00
-.1586-01	.4303-00
-.1586-01	-.4303-00
-.8637+01	.1000+01
-.8637+01	-.1000+01
-.1904+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

30

X(2)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.1660+02

BODE GAIN = -.9462+02

ROOTS

REAL PART	IMAGINARY PART
-.2082-06	.0000
-.1130+02	.0000
-.1896+01	.0000
-.1621-00	.0000
-.3990-00	.0000
-.5886-01	.4312-00
-.5886-01	-.4312-00
.4420-00	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.7713-01

BODE GAIN = -.1704+03

ROOTS

REAL PART	IMAGINARY PART
-.1159+00	.0000
.1409+03	.0000
-.6178-01	.3726-00
-.6178-01	-.3726-00
-.1159+02	.0000
-.1592+01	.0000
-.1046+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

31

X(4)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .4432+01

BODE GAIN = -.1748+02

ROOTS

REAL PART	IMAGINARY PART
-.5075-08	.0000
.5410-08	.0000
-.9778+01	.0000
-.1903+01	.0000
-.3032-01	.4355-00
-.3032-01	-.4355-00
-.6536-01	.3806-00
-.6536-01	-.3806-00
-.1518-00	.0000
.0000	.0000

X(5)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .3951-00

BODE GAIN = -.4397-04

ROOTS

REAL PART	IMAGINARY PART
-.7858-03	.0000
-.1152+02	.0000
-.1448+01	.0000
-.6114-01	.3722-00
-.6114-01	-.3722-00
-.1105+00	.0000
-.1099-01	.0000
.8601-09	.7139-08
.8601-09	-.7139-08
-.1624-06	.0000

X(6)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN=   .9024-00

BODE GAIN =   .2731-04

ROOTS

REAL PART	IMAGINARY PART
-.3602-03	.0000
.2100+01	.0000
-.1736-01	.0000
-.1368-00	.0000
-.1806+01	.0000
-.6018-01	.4315-00

-.6018-01	-.4315-00
-.8212-08	.0000
.3725-08	.0000
.5052-08	.0000

X(1)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   -.2544-00

BODE GAIN =   -.1372+01

ROOTS

REAL PART	IMAGINARY PART
-.2262-06	.0000
-.9758+01	.0000
-.1923+01	.0000
-.1133+00	.3265-00
-.1133+00	-.3265-00
.6167-00	.0000
.2236-01	.2809-00
.2236-01	-.2809-00
.2171-07	.0000
.0000	.0000

33

X(2)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.2185-02

BODE GAIN = .8635-00

ROOTS

REAL PART	IMAGINARY PART
.3055-05	.0000
.3308+03	.0000
.9341+01	.0000
-.1127+00	.6528-01

-.1127+00	-.6528-01
-.1373+01	.0000
-.1751-00	.2849-00
-.1751-00	-.2849-00
.0000	.0000
.0000	.0000

X(3)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.1050+02

BODE GAIN = .8973+01

ROOTS

REAL PART	IMAGINARY PART
-.1450-00	.5824-01
-.1450-00	-.5824-01
-.2477-00	.0000
-.8387-01	.3664-00
-.8387-01	-.3664-00
-.9612+01	.0000
-.2076+01	.0000
.3632-07	.0000
.0000	.0000
.0000	.0000

X(4)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   .4747-01

BODE GAIN = -.1872-00

ROOTS

REAL PART	IMAGINARY PART
-.1482-00	.3894-00
-.1482-00	-.3894-00
.2266-01	.3462-00
.2266-01	-.3462-00
-.1010+02	.0000
-.2138+01	.0000
-.1780-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(5)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.1170+00

BODE GAIN =   .3201-00

ROOTS

REAL PART	IMAGINARY PART
.3678-06	.0000
-.1010+02	.0000
.0000	.0000
.1007+01	.0000
-.8313-01	.3649-00
-.8313-01	-.3649-00
-.1758-00	.9057-01
-.1758-00	-.9057-01
.1881-08	.0000
.7178-08	.0000

X(6)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.2986-01

BODE GAIN = .2924-06

ROOTS

REAL PART	IMAGINARY PART
.6266-04	.0000
.8683+01	.0000
-.2087-00	.3069-00
-.2087-00	-.3069-00
-.5160-02	.1276-00
-.5160-02	-.1276-00
-.1630-00	.0000
-.9003-08	.0000
.3260-08	.0000
.2971-08	.0000

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LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 5 SPEED= 0.0 FT/SEC. H-DOT= 0.0 FT/SEC. GAMMA= 0.0 DEG.
GROSS WEIGHT=15600, SEA LEVEL, DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.7472+01	.1497+01	-.1463+01	-.5297+03	.1477+04	-.3821+01
Y	-.1286+01	-.2319+02	-.2918-00	-.1461+04	-.4988+03	.3697+03
Z	-.5452+01	.5622-01	-.1196+03	.1114+03	-.6026+02	.1113+04
L	-.8811+02	-.4463+03	.1557+01	-.8668+03	.1095+05	.2073+04
M	.4719+03	-.8280+02	-.3912+02	-.9807+04	-.8756+05	.2043+04
N	-.6650+01	.3419+03	-.7823+01	.5119+03	-.3515+04	-.1861+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.5022-03	-.1685-03	-.1560-01	-.2309+02	-.2106+01	.4496-00
Y	-.5985-04	.7061-04	-.7837-02	.2101+01	-.2317+02	-.4429-01
Z	.1504-02	.1420-02	.1967-02	.7802-00	.3740-00	.5083-01
L	.8433-02	.8390-02	.8830-02	.2963+04	-.1429+04	-.6241+02
M	.7970-02	.1109-05	.3172-00	.1430+04	.2957+04	-.2799+02
N	-.1131-02	-.1099-03	.2448-02	-.7558+02	.3245+02	.9843+01

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.4503+03	-.5280+04	.1958+05	-.8316+01	-.4335+04
Y	-.2294+03	.1960+05	.5283+04	.9279+04	.1139-02
Z	-.1114+06	.1099+03	-.4693+03	-.6556+01	.8758+02
L	.2598+04	.6926+06	.2757+06	.2273+04	-.3061+03
M	-.1539+05	.2757+06	-.6920+06	-.6124+04	.3686+04
N	.2881+06	-.1954+05	-.7500+04	-.2807+06	.4575+01

THE INERTIA TENSOR

.1152+05	.0000	.9126+03
.0000	.5000+05	.0000
.9126+03	.0000	.5498+05

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.9998-00	-.0000	.2098-01	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.2381-00	.5286-03	-.4719-02	.1735-00	.2094+01	-.6410-02

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= .1959-05   PHI=-.6409-01
AIRCRAFT INERTIAL SPEED= .1000+01

DENOMINATOR CHARACTERISTIC
ROOTS

REAL PART	IMAGINARY PART
-.2348-00	.0000
-.2047-00	.0000
.3452-01	.4150-00
.3452-01	-.4150-00
-.1825-01	.3937-00
-.1825-01	-.3937-00
-.1001+02	.0000
-.2010+01	.0000
.2177-07	.0000
.0000	.0000
.0000	.0000
.0000	.0000

NUMERATORS
(NOTE- NUMERATOR ROOTS LESS THAN 1.0E-7 TIMES THE
LARGEST NUMERATOR ROOT ARE NOT INCLUDED IN THE BODE GAIN).

X(1)-TO-C(1) NUMERATOP

ROOT LOCUS GAIN=   .9044-00

BODE GAIN =   -.4880+03

ROOTS

REAL PART	IMAGINARY PART
-.2241-00	.0000
-.9363-02	.4055-00
-.9363-02	-.4055-00
-.9924+01	.0000
-.4648+01	.0000
.1047+01	.2676+01
.1047+01	-.2676+01
.0000	.0000
.0000	.0000
.0000	.0000

38

X(2)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .4551-00

BODE GAIN = .1912+03

ROOTS

REAL PART	IMAGINARY PART
.1091-06	.0000
-.2448-00	.0000
.5471-02	.4507-00
.5471-02	-.4507-00
-.4956+01	.4518+01
-.4956+01	-.4518+01
-.3728+01	.0000
.1312+01	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .2299+03

BODE GAIN = -.6408+03

ROOTS

REAL PART	IMAGINARY PART
-.1337-00	.0000
-.1001+02	.0000
-.2012+01	.0000
-.1971-01	.3929-00
-.1971-01	-.3929-00
.3304-01	.4159-00
.3304-01	-.4159-00
.0000	.0000
.0000	.0000
.0000	.0000

39

X(4)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .2376-00

BODE GAIN = -.5731-04

ROOTS

REAL PART	IMAGINARY PART
.1421-03	.0000
.4294+01	.0000
.8923-02	.4511-00
.8923-02	-.4511-00
-.3070+01	.0000
-.2391-00	.0000
-.6886-01	.0000
.2771-07	.0000
.9740-08	.0000
.1872-08	.0000

X(5)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .3390-00

BODE GAIN = -.1873+01

ROOTS

REAL PART	IMAGINARY PART
-.4008-00	.0000
-.2903-00	.0000
-.8566-02	.4060-00
-.8566-02	-.4060-00
-.9617+01	.0000
.8486-00	.2436-00
.8486-00	-.2436-00
-.9504-04	.0000
.0000	.0000
.0000	.0000

40

X(6)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.5245+01

BODE GAIN = .2919+02

ROOTS

REAL PART	IMAGINARY PART
-.1086-01	.4090-00
-.1086-01	-.4090-00
.4852-01	.4054-00
.4852-01	-.4054-00
-.9995+01	.0000
-.2014+01	.0000
-.2578-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .1474+02

BODE GAIN = -.1017+04

ROOTS

REAL PART	IMAGINARY PART
.1834-07	.0000
-.1114+02	.0000
-.1222+01	.2612+01
-.1222+01	-.2612+01
.1008+00	.4432-00
.1008+00	-.4432-00
-.4162-00	.0000
-.2256-00	.0000
.0000	.0000
.0000	.0000

41

X(2)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.4041+02

BODE GAIN = .1916+04

ROOTS

REAL PART	IMAGINARY PART
.4600-08	.0000
.9657-07	.0000
-.1850+01	.7672+01
-.1850+01	-.7672+01
.3831-01	.4082-00
.3831-01	-.4082-00
-.2110+01	.0000
-.2360-00	.1408-01
-.2360-00	-.1408-01
-.2098-07	.0000

X(3)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.3616-00

BODE GAIN = .5304+03

ROOTS

REAL PART	IMAGINARY PART
.0000	.0000
-.4505-07	.0000
-.5735+02	.0000
-.9202+01	.0000
-.1715+01	.0000
-.1365-00	.4801-00
-.1365-00	-.4801-00
.4587-01	.4089-00
.4587-01	-.4089-00
.0000	.0000

42

X(4)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.7976+02

BODE GAIN = -.1011-03

ROOTS

REAL PART	IMAGINARY PART
.1748-06	.0000
-.2072+01	.0000
-.2310-00	.7127-02
-.2310-00	-.7127-02
-.3150-01	.0000
.3824-01	.4085-00
.3824-01	-.4085-00
.5622-04	.0000
.6054-08	.0000
.0000	.0000

X(5)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.8286+01

BODE GAIN = -.3303+01

ROOTS

REAL PART	IMAGINARY PART
-.2555-00	.0000
.2754-00	.0000
.7938-01	.4414-03
.7938-01	-.4414-00
-.5165+01	.0000
-.3124-00	.2106-00
-.3124-00	-.2106-00
.1863-08	.0000
.0000	.0000
.0000	.0000

X(6)=TO-C(2) NUMERATOR

ROOT LOCUS GAIN=   .1784+01

BODE GAIN =   .5147+02

ROOTS

REAL PART	IMAGINARY PART
-.6672-08	.0000
-.1793+01	.0000
-.2483-00	.0000
.3999-01	.4085-00
.3999-01	-.4085-00
-.1812+01	.1708+01
-.1812+01	-.1708+01
.1615+01	.0000
.0000	.0000
.0000	.0000

X(1)=TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3883+02

BODE GAIN =   .1391+04

ROOTS

REAL PART	IMAGINARY PART
-.1913-00	.0000
-.2312-00	.0000
-.3474-01	.4021-00
-.3474-01	-.4021-00
-.9847+01	.0000
-.2380-00	.3618+01
-.2380-00	-.3618+01
-.4221-13	.0000
.0000	.0000
.0000	.0000

44

X(2)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.1171+02

BODE GAIN = .4227-02

ROOTS

REAL PART	IMAGINARY PART
.1140-04	.0000
-.1511+01	.1050+02
-.1511+01	-.1050+02
.4871-01	.3398-00

REAL PART	IMAGINARY PART
.4871-01	-.3398-00
-.1113+01	.0000
-.2357-00	.1528-01
-.2357-00	-.1528-01
-.1878-08	.0000
.0000	.0000

X(3)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .9235-00

BODE GAIN = .1643+02

ROOTS

REAL PART	IMAGINARY PART
.5696-01	.0000
-.1019+02	.2299+01
-.1019+02	-.2299+01
-.7313-01	.4063-00
-.7313-01	-.4063-00
.4636-00	.4711-00
.4636-00	-.4711-00
.0000	.0000
.0000	.0000
.0000	.0000

45

X(4)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3459+02

BODE GAIN = -.1746-04

ROOTS

REAL PART	IMAGINARY PART
-.1218-06	.0000
-.1319+01	.0000
-.2306-00	.7493-02
-.2306-00	-.7493-02
-.3359-01	.0000
.5222-01	.3424-00
.5222-01	-.3424-00
.4644-04	.0000
.1723-07	.0000
.0000	.0000

X(5)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .1368+02

BODE GAIN = -.5688-00

ROOTS

REAL PART	IMAGINARY PART
.2955-01	.9544-01
.2955-01	-.9544-01
-.2370-00	.2447-01
-.2370-00	-.2447-01
-.1141+02	.0000
-.3392-01	.4079-00
-.3392-01	-.4079-00
.1627-08	.0000
-.3765-09	.0000
.0000	.0000

X(6)=TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .7663-00

BODE GAIN = -.3401-05

ROOTS

REAL PART	IMAGINARY PART
-.6301-08	.0000
-.3837-06	.0000
-.3799+01	.0000
-.2510-00	.0000
.5794-01	.3188-00
.5794-01	-.3188-00
.3139+01	.0000
-.5245-00	.8262-00
-.5245-00	-.8262-00
.0000	.0000

X(1)=TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .6276-01

BODE GAIN = .3906+03

ROOTS

REAL PART	IMAGINARY PART
.5937-09	.0000
-.2384+02	.0000
-.8792+01	.0000
-.1749+01	.0000
-.2263-00	.0000
.1238+02	.0000
.7058-04	.3972-00
.7058-04	-.3972-00
.0000	.0000
.0000	.0000

47

X(2)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.1916+02

BODE GAIN = -.1576+03

ROOTS

REAL PART	IMAGINARY PART
-.1940-07	.0000
-.9623+01	.0000
-.2030+01	.0000
-.7729-00	.0000
-.2413-00	.0000
.1444-01	.4207-00
.1444-01	-.4207-00
.3317-00	.0000
.3381-13	.0000
.0000	.0000

X(3)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN=   .1270-01

BODE GAIN = -.2715+03

ROOTS

REAL PART	IMAGINARY PART
-.1306-01	.4040-00
-.1306-01	-.4040-00
.3826-01	.4279-00
.3826-01	-.4279-00
-.9195+03	.0000
-.1002+02	.0000
-.2002+01	.0000
.4001-07	.0000
-.1749-09	.0000
.0000	.0000

48

X(4)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.8661-00

BODE GAIN = .5314-04

ROOTS

REAL PART	IMAGINARY PART
-.3885-08	.0000
.2816+01	.0000
-.2373-00	.0000
-.1213+00	.0000
.5606-04	.0000
-.1966+01	.0000
.1461-01	.4225-00
.1461-01	-.4225-00
.2137-07	.0000
.4191-08	.0000

X(5)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .1008+00

BODE GAIN = .1736+01

ROOTS

REAL PART	IMAGINARY PART
-.2562-00	.0000
-.1654+02	.0000
-.1044+01	.2237-00
-.1044+01	-.2237-00
.1005-02	.3978-00
.1005-02	-.3976-00
.5872-00	.0000
.5472-07	.0000
.1079-07	.0000
.0000	.0000

49

X(6)=TO-C(4) NUMERATOR

ROOT LOCUS GAIN=   .5122+01

BODE GAIN = -.2706+02

ROOTS

REAL PART	IMAGINARY PART
-.2445-02	.4028-00
-.2445-02	-.4028-00
.4942-01	.4103-00
.4942-01	-.4103-00
-.9965+01	.0000
-.2010+01	.0000

-.2478-00	.0000
-.1597-08	.0000
.1863-08	.0000
.0000	.0000

X(1)=TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   .8946+01

BODE GAIN = -.7967+01

ROOTS

REAL PART	IMAGINARY PART
-.9811-08	.0000
-.1000+02	.0000
-.1714+01	.0000
-.2141-00	.0000
-.2452-00	.0000
-.2298-01	.4058-00
-.2298-01	-.4058-00
-.1559-00	.0000
-.6265-12	.0000
.0000	.0000

X(2)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   ,388A-02

BODE GAIN =   ,9842-00

ROOTS

REAL PART	IMAGINARY PART
-,2344-07	,0000
,6269+01	,2337+02
,6269+01	-,2337+02
,2800+01	,0000
-,1886-00	,2394-00
-,1886-00	-,2394-00
-,2418-00	,0000
-,1791-00	,0000
,7177-09	,0000
,0000	,0000

X(3)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -,1807-00

BODE GAIN =   ,1385+01

ROOTS

REAL PART	IMAGINARY PART
-,1830-00	,0000
-,9998+01	,0000
-,2647+01	,0000
-,4157-01	,4903-00
-,4157-01	-,4903-00
-,7550-01	,4055-00
-,7550-01	-,4055-00
-,1019-10	,0000
-,5087-07	,0000
,0000	,0C00

51

X(4)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .4897-01

BODE GAIN = -.6060-07

ROOTS

REAL PART	IMAGINARY PART
.6062-04	.0000
.3188+01	.0000
-.1366-00	.0000
-.2447-00	.1446-00
-.2447-00	-.1446-00
-.2404-00	.0000
-.6283-01	.0000
.3492-09	.2122-0
.3492-09	-.2122-0
-.7519-08	.0000

X(5)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.7686-01

BODE GAIN = -.1986-02

ROOTS

NOT REPRODUCIBLE

REAL PART	IMAGINARY PART
-.7053-02	.0000
-.1046+02	.0000
-.2313-00	.0000
-.2088-00	.0000
.1145+01	.0000
-.2305-01	.4052-00
-.2305-01	-.4052-00
.6352-08	.0000
-.1564-08	.0000
.0000	.0000

52

X(6)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.1009-02

BODE GAIN = .3095-01

ROOTS

REAL PART	IMAGINARY PART
.2501-07	.0000
-.8002-07	.0000
.8131+01	.0000
.2191+01	.0000
-.1390-00	.0000
-.2684-00	.0000
-.4505+01	.0000
-.1897-00	.4802-00
-.1897-00	-.4802-00
.0000	.0000

LOCKHEED AH56A HELICOPTER   JUNE 1C 1970   MOSTAB-B DERIVATIVES
CASE A   SPEED= 33.6 FT/SEC,   H-DOT= 0.0 FT/SEC,   GAMMA= 0.0 DEG.
GROSS WEIGHT=15600.   SEA LEVEL, DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.3264+02	.1739+01	-.4548+01	-.4565+03	.1559+04	-.3215+02
Y	.3881+01	-.2999+02	-.9127-00	-.1551+04	-.4387+03	.5097+03
Z	-.1103+03	-.1016+01	-.1742+03	.2095+02	.7170+02	.9901+03
L	-.8124+02	-.4130+03	-.5713+01	-.8602+05	.1009+05	.1204+04
M	.3872+03	-.7177+02	-.1040+03	-.9465+04	-.9104+05	.2396+04
N	-.2094+03	.3463+03	-.4293+02	-.3981+02	-.1408+04	-.1651+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.7724-03	.1432-03	-.5680-01	-.2447+02	-.1226+01	.3508-00
Y	.8408-03	.1283-04	.5788-01	.1329+01	-.2486+02	-.3315-01
Z	.2364-03	-.1179-02	.1668-C1	.5917+C1	.1027+01	-.1032-01
L	.6179-01	.2949-02	.4202+01	.2971+04	-.1417+04	-.4676+02
M	.2835-01	-.4172-01	.2251+01	.1424+04	.2965+04	-.1973+02
N	-.7220-03	-.1581-02	-.1460-00	-.8690+02	.2634+02	.1003+02

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.1371+04	-.5468+04	.1833+05	-.2170+03	-.6624+04
Y	-.7189+03	.1885+05	.5495+04	.8205+04	.6254-03
Z	-.1058+06	.1296+04	.4231+04	.1311+02	.1000+03
L	-.1588+05	.6904+06	.2748+06	.3285+04	-.1414+04
M	.8321+05	.2762+06	-.6927+06	-.4021+04	.5690+04
N	.2486+06	-.2114+05	-.4184+04	-.2494+06	-.2227+02

THE INERTIA TENSOR

.1151+05	.0000	.6790+03
.0000	.5000+05	.0000
.6790+03	.0000	.5499+05

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.3380+02	-.0000	.5276-00	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

| .2184-00 | -.2581-02 | .1298-01 | .1401-C0 | .1559-01 | -.5144-01 |

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= .2442-05   PHI =-.5143-01
AIRCRAFT INERTIAL SPEED= .3380+02

DENOMINATOR CHARACTERISTIC
ROOTS

REAL	IMAGINARY
PART	PART
-.1106+00	.0000
-.9938+01	.0000
-.2021+01	.0000
-.1151+00	.5842-00
-.1151+00	-.5842-00
.9455-02	.3617-00
.9455-02	-.3617-00
-.3995-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000
.0000	.0000

NUMERATORS
(NOTE- NUMERATOR ROOTS LESS THAN 1.0E-7 TIMES THE
LARGEST NUMERATOR ROOT ARE NOT INCLUDED IN THE BODE GAIN).

X(1)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .2672+01

BODE GAIN = -.6672+03

ROOTS

REAL	IMAGINARY
PART	PART
.4215-07	.0000
-.8022-00	.0000
-.1934-00	.0000
-.1467-00	.5047-00
-.1467-00	-.5047-00
-.9918+01	.0000
.6122-00	.4925+01
.6122-00	-.4925+01
.0000	.0000
.0000	.0000

55

X(2)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .1604+01

BODE GAIN = .1417+03

ROOTS

REAL PART	IMAGINARY PART
.1826-07	.0000
-.8742+02	.0000
-.1133+02	.0000
-.1959+01	.0000

-.4540-00	.0000
.1864-01	.3996-00
.1864-01	-.3996-00
.2582-01	.0000
.2065-07	.0000
.0000	.0000

X(3)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .2184+03

BODE GAIN = -.2261+02

ROOTS

REAL PART	IMAGINARY PART
-.5958-02	.0000
-.9963+01	.0000
-.1803+01	.0000
+.1121+00	.5859-00
-.1121+00	-.5859-00
-.8790-02	.3345-00
-.8790-02	-.3345-00
.0000	.0000
.0000	.0000
.0000	.0000

56

X(4)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .2633+01

BODE GAIN = -.6589-04

ROOTS

REAL PART	IMAGINARY PART
.1030-08	.0000
-.1474+01	.6957-00
-.1474+01	-.6957-00
-.4854-00	.0000
.2364-05	.0000
.2036+01	.0000
.1653-01	.4071-00
.1653-01	-.4071-00
.0000	.0000
.1257-07	.0000

X(5)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.1677+01

BODE GAIN = -.1386+01

ROOTS

REAL PART	IMAGINARY PART
-.1732-00	.2243-00
-.1732-00	-.2243-00
-.1035+02	.0000
-.1861-00	.5525-00
-.1861-00	-.5525-00
-.6204-00	.0000
.1850-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

57

X(6)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.4560+01

BODE GAIN = .2692+02

ROOTS

REAL PART	IMAGINARY PART
-.9706-08	.0000
-.9847+01	.0000
-.2036+01	.0000
-.3319-01	.3960-00
-.3319-01	-.3960-00
.4901-01	.4027-00
.4901-01	-.4027-00
-.4667-00	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .1533+02

BODE GAIN = -.1021+04

ROOTS

REAL PART	IMAGINARY PART
.2197-07	.0000
-.1009+02	.0000
-.1219+01	.2760+01
-.1219+01	-.2760+01
-.4190-02	.5664-00
-.4190-02	-.5664-00
-.3840-00	.0000
-.2426-00	.0000
.0000	.0000
.0000	.0000

58

X(2)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.3870+02

BODE GAIN = .1943+04

ROOTS

REAL PART	IMAGINARY PART
-.2017-06	.0000
-.2160+01	.7961+01
-.2160+01	-.7961+01
-.2107+01	.0000
-.4128-00	.0000
.1625-01	.3361-00
.1625-01	-.3361-00
-.3085-00	.0000
.0000	.0000
.8754-07	.0000

X(3)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.3665+01

BODE GAIN = .9324+03

ROOTS

REAL PART	IMAGINARY PART
.2823-02	.4312-00
.2823-02	-.4312-00
-.9690-01	.5924-00
-.9690-01	-.5924-00
-.8147+02	.0000
-.5439+01	.0000
-.3530-00	.0000
.2114-07	.0000
.0000	.0000
.0000	.0000

X(4)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.7961+02

BODE GAIN = -.1229-03

ROOTS

REAL PART	IMAGINARY PART
.2280-05	.0000
-.2085+01	.0000
-.2081-00	.4508-00
-.2081-00	-.4508-00
.4306-01	.3672-00
.4306-01	-.3672-00
-.3972-00	.0000
-.8124-08	.0000
.4717-08	.0000
.0000	.0000

X(5)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.8283+01

BODE GAIN = -.2586+01

ROOTS

REAL PART	IMAGINARY PART
-.3924-00	.0000
-.2128-00	.2424-00
-.2128-00	-.2424-00
.2055-00	.0000
-.5200+01	.0000
-.4778-01	.5406-00
-.4778-01	-.5406-00
-.3893-09	.0000
.0000	.0000
.0000	.0000

X(6)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN=   .1490+01

BODE GAIN =   .5023+02

ROOTS

REAL PART	IMAGINARY PART
.1089-01	.3705-00
.1089-01	-.3705-00
-.3951-00	.0000
-.2389+01	.0000
-.1977+01	.1564+01
-.1977+01	-.1564+01
.1685+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3613+02

BODE GAIN =   .1773+04

ROOTS

REAL PART	IMAGINARY PART
-.1184+00	.0000
-.9916+01	.0000
-.2007-00	.3753+01
-.2007-00	-.3753+01
-.1113+00	.5791-00
-.1113+00	-.5791-00
-.3505-00	.0000
.0000	.0000
.2197-07	.0000
.0000	.0000

61

X(2)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.1214+02

BODE GAIN = .3109+03

ROOTS

REAL PART	IMAGINARY PART
-.5395-01	.0000
-.2100+01	.1022+02
-.2100+01	-.1022+02
-.4294-02	.6639-00

-.4294-02	-.6639-00
-.1407+01	.0000
-.2895-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.9126+01

BODE GAIN = -.1174+04

ROOTS

REAL PART	IMAGINARY PART
-.1240+00	.0000
.5124+02	.0000
-.1138+00	.5632-00
-.1138+00	-.5632-00
-.1093+02	.0000
-.1399-01	.4647-00
-.1399-01	-.4647-00
.0000	.0000
.0000	.0000
.0000	.0000

62

X(4)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3457+02

BODE GAIN = .3237-04

ROOTS

REAL PART	IMAGINARY PART
-.3389-07	.0000
-.1249+01	.0000
-.6843-00	.0000
-.2088-00	.0000
.2360-05	.0000
-.7174-01	.6154-00
-.7174-01	-.6154-00
.2390-00	.0000
.0000	.0000
-.4191-08	.0000

X(5)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .1368+02

BODE GAIN = .6809-00

ROOTS

REAL PART	IMAGINARY PART
-.1190+00	.8146-01
-.1190+00	-.8146-01
.7173-01	.0000
-.3474-00	.0000
-.1131+02	.0000
-.1146+00	.5800-00
-.1146+00	-.5600-00
-.4657-09	.0000
.0000	.0000
.0000	.0000

63

X(6)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN=   .5634-00

BODE GAIN = -.1323+02

ROOTS

REAL PART	IMAGINARY PART
-.2280-00	.0000
-.6984-01	.4544-00
-.6984-01	-.4544-00
-.2643+01	.1759+01
-.2643+01	-.1759+01
.1406+01	.1142+00
.1406+01	-.1142+00
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN=   .4905-00

BODE GAIN =   .2770+03

ROOTS

REAL PART	IMAGINARY PART
-.1026-06	.0000
-.1001+02	.0000
-.5046+01	.0000
-.2082+01	.0000
-.3302-00	.0000
.4850+01	.0000
-.8364-01	.3620-00
-.8364-01	-.3620-00
.0000	.0000
.0000	.0000

64

X(2)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.1694+02

BODE GAIN = -.7497+02

ROOTS

REAL PART	IMAGINARY PART
.1748-01	.0000
-.9434+01	.1660+01
-.9434+01	-.1660+01
-.2021+01	.0000
.9171-02	.3698-00
.9171-02	-.3698-00
-.4107-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.3653-01

BODE GAIN = -.2859+03

ROOTS

REAL PART	IMAGINARY PART
-.2757-01	.3713-00
-.2757-01	-.3713-00
-.9043-01	.5586-00
-.9043-01	-.5586-00
.3116+03	.0000
-.1130+02	.0000
-.2062+01	.0000
-.1397-07	.0000
.0000	.0000
.0000	.0000

65

X(4)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.7813-00

BODE GAIN = .2062+02

ROOTS

REAL PART	IMAGINARY PART
.2218-07	.0000
-.2316+01	.0000
-.1988+01	.0000
-.4163-00	.0000
.0000	.0000
.4107+01	.0000
.8699-02	.3716-00
.8699-02	-.3716-00
-.4074-08	.0000
-.1397-07	.0000

X(5)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .5995-01

BODE GAIN = .1006+01

ROOTS

REAL PART	IMAGINARY PART
-.6719-01	.3412-00
-.6719-01	-.3412-00
-.5715-00	.9752-01
-.5715-00	-.9752-01
-.1946+02	.0000
-.2180+01	.0000
.4004-00	.0000
-.2445-08	.0000
.0000	.0000
.0000	.0000

66

X(6)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .4547+01

BODE GAIN = -.1953+02

ROOTS

REAL PART	IMAGINARY PART
-.1090-01	.3803-00
-.1090-01	-.3803-00
.1981-01	.3839-00
.1981-01	-.3839-00
-.9912+01	.0000
-.2021+01	.0000
-.4129-00	.0000
-.8163-09	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .1366+02

BODE GAIN = -.1461+02

ROOTS

REAL PART	IMAGINARY PART
.1713-07	.0000
-.9938+01	.0000
-.1721+01	.0000
-.1696-00	.0000
-.9781-01	.0000
-.1048+00	.5809-00
-.1048+00	-.5809-00
-.4455-00	.0000
.0000	.0000
.0000	.0000

67

X(2)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .6426-02

BODE GAIN = -.4520-00

ROOTS

REAL PART	IMAGINARY PART
-.2687-01	.0000
-.5236-01	.0000
.2027+02	.3410+02
.2027+02	-.3410+02

-.1119+01	.1170+01
-.1119+01	-.1170+01
-.4991-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.2044-00

BODE GAIN = .1066+02

ROOTS

REAL PART	IMAGINARY PART
.3803-08	.0000
-.3557+02	.0000
-.1059+02	.0000
-.1189+00	.5861-00
-.1189+00	-.5861-00
-.1576-00	.3629-00
-.1576-00	-.3629-00
-.1018+00	.0000
.0000	.0000
.0000	.0000

68

X(4)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .1849-00

BODE GAIN = -.9114-13

ROOTS

REAL PART	IMAGINARY PART
-.3011-07	.0000
.2516-06	.0000
-.9461-00	.0000
-.5101-00	.0000
-.8028-01	.0000
.2362-05	.0000
-.2443-00	.8698-00
-.2443-00	-.8698-00
.1080+01	.0000
.3073-08	.0000

X(5)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.1154+00

BODE GAIN = -.7591-02

ROOTS

REAL PART	IMAGINARY PART
-.1834-06	.0000
-.1083+02	.0000
-.3844-00	.0000
-.1187+00	.0000
-.1744-01	.0000
-.1019+00	.5845-00
-.1019+00	-.5845-00
.8932-00	.0000
.3291-08	.0000
.0000	.0000

69

X(6)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.2226-02

BODE GAIN = .1475-00

ROOTS

REAL PART	IMAGINARY PART
-.7976-01	.0000
-.1537-01	.4289-00
-.1537-01	-.4289-00
-.5057-00	.0000
-.9247+01	.1170+02
-.9247+01	-.1170+02
-.1651+01	.0000
-.5577-08	.0000
.0000	.0000
.0000	.0000

70

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 7   SPEED= 67.8 FT/SEC.   H-DOT= 0.0 FT/SEC.   GAMMA= 0.0 DEG.
GROSS WEIGHT=15600.   SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.5455+01	.1975+01	-.6974+01	-.3769+03	.1833+04	.2740+02
Y	.2306+01	-.4014+02	-.2003+01	-.1720+04	-.3291+03	.7446+03
Z	-.8543+02	-.1667+01	-.2714+03	-.2952+03	.1340+02	.9385+03
L	-.7168+02	-.3586+03	-.1603+02	-.8488+05	.9335+04	.1047+04
M	.4621+03	-.5614+02	-.9420+02	-.9127+04	-.9449+05	.3156+04
N	-.2411+03	.4613+03	-.1836+03	.1617+03	.1057+04	-.2266+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.2114-02	.7536-04	-.1086+05	-.2874+02	.3133-00	.5528-00
Y	.2036-02	.4582-04	.1019+00	.4736-01	-.2907+02	-.6376-02
Z	.2034-03	-.1261-02	.1063-01	.1965+01	.9481-00	-.9516-02
L	.1696-00	.9922-02	.6397+01	.2985+04	-.1400+04	-.5943+02
M	.7925-01	-.4330-01	.4253+01	.1614+04	.2976+04	-.2725+02
N	-.1222-01	-.5319-02	-.4423-00	-.1369+03	.4022+02	.1123+02

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.1094+05	-.6204+04	.1891+05	-.2742+03	-.8825+04
Y	-.1464+04	.1779+05	.6050+04	.7612+04	.3080-02
Z	-.1153-00	.4356+03	.1825+05	.1790+02	.1757+03
L	-.3321+05	.6870+06	.2739+06	.2017+04	-.2942+04
M	.1635+06	.2770+06	-.6933+06	-.1740+04	.7722+04
N	.1798+06	-.3136+05	.4861+04	-.2318+06	-.6205+02

THE INERTIA TENSOR

```
.1152+05    .0000    .8657+03
.0000    .5000+05    .0000
.8657+03    .0000    .5498+05
```

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.6779+02	-.0000	.1349+01	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.1670-00   -.5276-02   .2692-01   .7512-01   .1990-01   -.3157-01

STABILITY AXIS SYSTEM EULER ANGLES- THETA= .1285-04   PHI -.3156-01
AIRCRAFT INERTIAL SPEED= .6780+02

71

DENOMINATOR CHARACTERISTIC
ROOTS

REAL PART	IMAGINARY PART
-.7186-01	.0000
-.9818+01	.0000
-.2066+01	.0000
.3199-01	.3790-00
.3199-01	-.3790-00
-.2039-00	.8160-00
-.2039-00	-.8160-00
-.6124-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000
.0000	.0000

NUMERATORS
(NOTE. NUMERATOR ROOTS LESS THAN 1.0E-7 TIMES THE
LARGEST NUMERATOR ROOT ARE NOT INCLUDED IN THE BODE GAIN).

X(1)=TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .2222+02

BODE GAIN =   -.6104+03

ROOTS

REAL PART	IMAGINARY PART
-.3463+07	.0000
-.9874+01	.0000
-.4571-00	.2221+01
-.4571-00	-.2221+01
-.2816-00	.7791-00
-.2816-00	-.7791-00
-.6996-00	.0000
-.1030+00	.0000
.0000	.0000
.0000	.0000

72

X(2)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .3264+01

BODE GAIN =   .7356+02

ROOTS

REAL	IMAGINARY
PART	PART
-.6297-08	.0000
-.6162+02	.0000
-.1163+02	.0000
-.2171+01	.0000

-.7195-00	.0000
.4252-01	.4577-00
.4252-01	-.4577-00
.8706-02	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=. .2380+03

BODE GAIN = -.1742+03

ROOTS

REAL	IMAGINARY
PART	PART
.2775-07	.0000
-.9892+01	.0000
-.4248-01	.0000
-.1761-00	.7843-00
-.1761-00	-.7843-00
-.1234+01	.0000
.8369-01	.4388-00
.8369-01	-.4388-00
.0000	.0000
.0000	.0000

73

X(4)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .5032+01

BODE GAIN = -.4260-16

ROOTS

REAL PART	IMAGINARY PART
.3677-06	.2365-06
.3677-06	-.2365-06
-.1312+01	.8794-00
-.1312+01	-.8794-00
-.7628-00	.0000
.3238-01	.4736-00
.3238-01	-.4736-00
.1524+01	.0000
.6192-05	.0000
.2692-08	.0000

X(5)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.3302+01

BODE GAIN = -.5466-00

ROOTS

REAL PART	IMAGINARY PART
-.8214-01	.1212+00
-.8214-01	-.1212+00
.1363-00	.0000
-.1068+02	.0000
-.2464-00	.8167-00
-.2464-00	-.8167-00
-.6658-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

74

X(6)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.3367+01

BODE GAIN = .1731+02

ROOTS

REAL PART	IMAGINARY PART
-.3966-01	.3739-00
-.3966-01	-.3739-00
.6994-01	.4507-00
.6994-01	-.4507-00
-.9482+01	.0000
-.2319+01	.0000
-.7262-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .1752+02

BODE GAIN = -.8953+03

ROOTS

REAL PART	IMAGINARY PART
-.1676-00	.0000
-.8793+01	.0000
-.1138+01	.2852+01
-.1138+01	-.2852+01
-.1217+00	.7753-00
-.1217+00	-.7753-00
-.5444-00	.0000
.6147-07	.0000
.0000	.0000
.0000	.0000

75

X(2)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.3625+02

BODE GAIN = .2180+04

ROOTS

REAL PART	IMAGINARY PART
.5417-01	.3359-00
.5417-01	-.3359-00
-.3569-00	.0000
-.2788+01	.8340+01
-.2788+01	-.8340+01
-.1958+01	.0000
-.8784-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.1236+01

BODE GAIN = .4424+03

ROOTS

REAL PART	IMAGINARY PART
.2458-01	.2988-00
.2458-01	-.2988-00
-.2379-00	.0000
-.4181+03	.0000
-.5612+01	.0000
-.1503-00	.7931-00
-.1503-00	-.7931-00
.0000	.0000
.0000	.0000
.0000	.0000

X(4)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.7946+02

BODE GAIN = .1589-09

ROOTS

REAL PART	IMAGINARY PART
.4636-08	.0000
.3195-07	.0000
-.2532-06	.0000
-.2138+01	.0000
-.2689-00	.7265-00
-.2689-00	-.7265-00
.5066-01	.3978-00
.5066-01	-.3978-00
-.5960-00	.0000
.5967-05	.0000

X(5)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.8281+01

BODE GAIN = -.1542+01

ROOTS

REAL PART	IMAGINARY PART
-.1284-00	.1873-00
-.1284-00	-.1873-00
.1765-00	.0000
-.5665-00	.0000
-.5205+01	.0000
-.1682-00	.7783-00
-.1682-00	-.7783-00
-.1863-08	.0000
.0000	.0000
.0000	.0000

77

X(6)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .2014+01

BODE GAIN = .4884+02

ROOTS

REAL PART	IMAGINARY PART
.2611-01	.3835-00
.2611-01	-.3835-00
-.5434-00	.0000
-.3058+01	.0000
-.1577+01	.1794+01
-.1577+01	-.1794+01
.1582+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3697+02

BODE GAIN = .1509+04

ROOTS

REAL PART	IMAGINARY PART
-.7242-01	.0000
-.1000+02	.0000
-.1632-00	.3715+01
-.1632-00	-.3715+01
-.2020-00	.9024-00
-.2020-00	-.9024-00
-.5439-00	.0000
.3604-09	.0000
-.3851-06	.0000
.0000	.0000

78

X(2)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.1329+02

BODE GAIN = .4750+03

ROOTS

REAL PART	IMAGINARY PART
-.6482-01	.0000
-.2352+01	.9392+01
-.2352+01	-.9392+01
.2804-00	.8384-00

.2804-00	-.8384-00
-.2533+01	.0000
-.2714-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3778+02

BODE GAIN = -.4192+03

ROOTS

REAL PART	IMAGINARY PART
-.7310-01	.0000
.2411+02	.0000
-.2035-00	.8064-00
-.2035-00	-.8064-00
-.1060+02	.0000
.1003-01	.2798-00
.1003-01	-.2798-00
.0000	.0000
.0000	.0000
.0000	.0000

79

X(4)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3444+02

BODE GAIN = -.1889-16

ROOTS

REAL PART	IMAGINARY PART
-.1401-06	.0000
-.1013+00	.0000
.3294-05	.0000
.7940-05	.0000
.1289-00	.0000
-.1146+01	.4080-00
-.1146+01	-.4080-00
-.7033-01	.8380-00
-.7033-01	-.8380-00
.0000	.0000

X(5)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .1370+02

BODE GAIN = .8766-01

ROOTS

REAL PART	IMAGINARY PART
-.5223-01	.9444-02
-.5223-01	-.9444-02
.4820-01	.0000
-.1115+02	.0000
-.2062-00	.8084-00
-.2062-00	-.8084-00
-.5547-00	.0000
-.3492-09	.0000
.0000	.0000
.0000	.0000

80

X(6)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .5500-00

BODE GAIN = -.2776+01

ROOTS

REAL PART	IMAGINARY PART
-.1065+00	.0000
-.1007+00	.3803-00
-.1007+00	-.3803-00
.3933-00	.0000
-.2431+01	.3658+01
-.2431+01	-.3658+01
.3686+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .6122-00

BODE GAIN = .1392+03

ROOTS

REAL PART	IMAGINARY PART
.4866-07	.0000
-.9454+01	.0000
-.3233+01	.1110+01
-.3233+01	-.1110+01
-.5467-00	.0000
.3332+01	.0000
-.1097+00	.3021-00
-.1097+00	-.3021-00
.0000	.0000
.0000	.0000

81

X(2)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.1571+02

BODE GAIN = -.4340+02

ROOTS

REAL PART	IMAGINARY PART
.7260-02	.0000
-.1778+02	.0000
-.1011+02	.0000
-.2063+01	.0000
.3094-01	.3856-00
.3094-01	-.3856-00
-.6258-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.3979-01

BODE GAIN = -.8469+02

ROOTS

REAL PART	IMAGINARY PART
.5323-01	.3167-00
.5323-01	-.3167-00
-.2023-00	.3963-00
-.2023-00	-.3963-00
.2430+03	.0000
-.1257+02	.0000
-.3118+01	.0000
.4191-08	.0000
.0000	.0000
.0000	.0000

82

X(4)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.6971-00

BODE GAIN =   .1527-03

ROOTS

REAL PART	IMAGINARY PART
.1380-07	.0000
-.2063-06	.0000
-.3523+01	.0000
-.1977+01	.0000
-.6304-00	.0000
.6080-05	.0000
.4980+01	.0000
.3033-01	.3867-00
.3033-01	-.3867-00
.6898-08	.0000

X(5)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .1360-01

BODE GAIN =   .3754-00

ROOTS

REAL PART	IMAGINARY PART
-.6766-01	.2823-00
-.6766-01	-.2823-00
-.5744-00	.1876-00
-.5744-00	-.1876-00
-.5650+02	.0000
-.4467+01	.0000
.3246-00	.0000
.5413-08	.0000
.0000	.0000
.0000	.0000

83

X(6)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN=   .4230+01

BODE GAIN = -.1189+02

ROOTS

REAL PART	IMAGINARY PART
-.1539-01	.3654-00
-.1539-01	-.3654-00
.3594-01	.3882-00
.3594-01	-.3882-00
-.9786+01	.0000
-.2061+01	.0000
-.6262-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   .1819+02

BODE GAIN = -.1638+02

ROOTS

REAL PART	IMAGINARY PART
.4324-07	.0000
-.9824+01	.0000
-.1717+01	.0000
-.7018-00	.0000
-.1615-00	.0000
-.2005-00	.8112-00
-.2005-00	-.8112-00
-.6162-01	.0000
.0000	.0000
.0000	.0000

84

X(2)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .8896-02

BODE GAIN = -.5210+01

ROOTS

REAL PART	IMAGINARY PART
-.3379-01	.6567-01
-.3379-01	-.6567-01
-.7490-00	.9650-00
-.7490-00	-.9650-00
.3901+02	.2694+02
.3901+02	-.2694+02
-.2925+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.3615-00

BODE GAIN = .5878+01

ROOTS

REAL PART	IMAGINARY PART
-.6407-01	.0000
-.3970+02	.0000
-.1084+02	.0000
-.1936-00	.8220-00
-.1936-00	-.8220-00
.1729-00	.2136-00
.1729-00	-.2136-00
.0000	.0000
.0000	.0000
.0000	.0000

85

X(4)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   .3724-00

BODE GAIN = -.9942-12

ROOTS

REAL PART	IMAGINARY PART
-.1951-07	.0000
.1212-04	.0000
.3093-05	.0000
-.6138-02	.0000
-.3200-00	.1007+01
-.3200-00	-.1007+01
-.1019+01	.4911-00
-.1019+01	-.4911-00
.7405-00	.0000
-.3089-07	.0000

X(5)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.1530-00

BODE GAIN = -.5635-03

ROOTS

REAL PART	IMAGINARY PART
-.8992-03	.0000
-.1105+02	.0000
-.7979-01	.0000
-.5673-00	.0000
-.1943-00	.8148-00
-.1943-00	-.8148-00
.1067+01	.0000
.7496-07	.0000
.5904-08	.0000
-.2980-07	.0000

86

X(6)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.5783-02

BODE GAIN = .1784-01

ROOTS

REAL PART	IMAGINARY PART
-.8042-02	.0000
-.5832+01	.1051+02
-.5832+01	-.1051+02
-.8525-00	.8689-00
-.8525-00	-.8689-00
-.3445-01	.4092-00
-.3445-01	-.4092-00
.0000	.0000
.0000	.0000
.0000	.0000

87

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   NOSTAB-B DERIVATIVES
CASE 8   SPEED=101.5 FT/SEC.   H-DOT= 0.0 FT/SEC.   GAMMA= 0.0 DEG.
GROSS WEIGHT=15600.   SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.4008+02	.2132+01	-.2276+02	-.3193+03	.1720+04	-.5985+02
Y	.9695-00	-.5148+02	-.2986+01	-.1691+04	-.2942+03	.9358+03
Z	-.4112+02	-.2088+01	-.3271+03	-.6424+03	-.9839+02	.1006+04
L	-.6280+02	-.3478+03	-.2099+02	-.9051+05	.8688+04	.1359+03
M	.2342+03	-.4468+02	-.1852+03	-.8254+04	-.9894+05	.2602+04
N	-.1215+03	.5793+03	-.2132+03	-.6710+02	.4148+04	-.2923+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	.5346-03	.3695-04	-.1624-00	-.2829+02	.5070-00	-.1068+00
Y	-.4126-03	.1091-04	.1320-00	.5661-01	-.2736+02	-.1015-02
Z	.2992-04	-.1185-02	-.7980-02	-.2529+01	.1754+01	-.1316-01
L	-.3629-01	.1167-01	.1240+02	.3003+04	-.1377+04	.9935+01
M	-.2538-01	-.4017-01	.6412+01	.1409+04	.2901+04	.4532+01
N	.3251-02	.1138-02	-.5710-00	-.1164+03	.1213+02	.8008+01

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.3191+04	-.6042+04	.1603+05	-.3648+03	-.1245+05
Y	-.2508+04	.1696+05	.6090+04	.9286+04	.3642-02
Z	-.1372+06	-.4912+03	.3567+05	.1968+02	-.5424+02
L	-.5486+05	.6866+06	.2696+06	.8980+04	-.7352+04
M	.3387+06	.2770+06	-.7256+06	-.6137+03	.1048+05
N	.1176+06	-.2227+05	.2886+05	-.2828+06	.1089+02

THE INERTIA TENSOR

```
.1150+05   -.3502-07   -.1438+03
-.3502-07   .5000+05   -.1308-09
-.1438+03   -.1308-09   .5500+05
```

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.1015+03	-.9231-10	-.3356-00	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.1781-00   -.6380-02   .3553-01   .4949-01   -.3305-02   -.2485-01

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= .3711-06   PHI -.2485-01
AIRCRAFT INERTIAL SPEED= .1015+03

DENOMINATOR CHARACTERISTIC
ROOTS

REAL PART	IMAGINARY PART
-.5207-01	.0000
-.1051+02	.0000
-.9338-00	.0000
-.3657-01	.2580-00
-.3657-01	-.2580-00
-.2812-00	.1060+01
-.2812-00	-.1060+01
-.1883+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000
.0000	.0000

NUMERATORS
(NOTE- NUMERATOR ROOTS LESS THAN 1.0E-7 TIMES THE
LARGEST NUMERATOR ROOT ARE NOT INCLUDED IN THE BODE GAIN).

X(1)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .5938+01

BODE GAIN = -.1872+04

ROOTS

REAL PART	IMAGINARY PART
.1954-08	.0000
-.7678-00	.0000
-.5997-01	.0000
-.3016-00	.1040+01
-.3016-00	-.1040+01
-.1076+02	.0000
.2243+01	.6133+01
.2243+01	-.6133+01
.31C7-08	.0000
.0000	.0000

X(2)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .5811+01

BODE GAIN = .1846+03

ROOTS

REAL PART	IMAGINARY PART
-.9869-07	.0000
-.2356+02	.0000
-.1912+02	.0000
-.2745+01	.0000

NOT REPRODUCIBLE

-.6814-00	.0000
.6320-02	.4141-00
.6320-02	-.4141-00
.1727-01	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .2831+03

BODE GAIN = -.1349+03

ROOTS

REAL PART	IMAGINARY PART
-.3250-07	.0000
-.1062+02	.0000
-.2909-00	.1025+01
-.2909-00	-.1025+01
-.3904-00	.0000
.4104-00	.2766-00
.4104-00	-.2766-00
-.3249-01	.0000
-.4018-08	.0000
.0000	.0000

90

X(4)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .7954+01

BODE GAIN = -.5155+02

ROOTS

REAL PART	IMAGINARY PART
-.2029-07	.0000
.9336-07	.0000
-.6343-00	.0000
.2887-02	.5268-00
.2887-02	-.5268-00
-.1185+01	.1215+01
-.1185+01	-.1215+01
.1005+01	.0000
.0000	.0000
.0000	.0000

X(5)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.6928+01

BODE GAIN = -.4074-00

ROOTS

REAL PART	IMAGINARY PART
-.7726-08	.0000
-.1118+02	.0000
-.2951-00	.1057+01
-.2951-00	-.1057+01
.3695-01	.0000
-.8103-00	.0000
-.8839-01	.6047-01
-.8839-01	-.6047-01
.0000	.0000
.0000	.0000

X(6)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.2139+01

BODE GAIN = .1639+02

ROOTS

REAL PART	IMAGINARY PART
-.1292-00	.3906-00
-.1292-00	-.3908-00
.1358-00	.3795-00
.1358-00	-.3795-00
-.1048+02	.0000
-.3100+01	.0000
-.6735-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .1710+02

BODE GAIN = -.1518+04

ROOTS

REAL PART	IMAGINARY PART
-.6910-07	.0000
-.5853-00	.0000
-.9773-01	.0000
-.9043+01	.0000
-.1127+01	.3289+01
-.1127+01	-.3289+01
-.2343-00	.1030+01
-.2343-00	-.1030+01
.0000	.0000
.0000	.0000

92

X(2)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.3455+02

BODE GAIN = .2218+04

ROOTS

REAL PART	IMAGINARY PART
.1093-02	.2373-00
.1093-02	-.2373-00
-.3779-00	.0000
-.1712+01	.8919+01
-.1712+01	-.8919+01
-.1539+01	.7105-00
-.1539+01	-.7105-00
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .1399+01

BODE GAIN = .3242+03

ROOTS

REAL PART	IMAGINARY PART
-.1435-01	.1679-00
-.1435-01	-.1679-00
-.1658-00	.0000
.5210+03	.0000
-.6470+01	.0000
-.2498-00	.1042+01
-.2498-00	-.1042+01
.1863-08	.0000
.0000	.0000
.0000	.0000

93

X(4)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.7944+02

BODE GAIN = -.1517+03

ROOTS

REAL PART	IMAGINARY PART
-.2971-01	.2796-00
-.2971-01	-.2796-00
-.8446-00	.0000
-.3337-00	.1003+01
-.3337-00	-.1003+01
-.2010+01	.0000
.1044-06	.0000
-.2275-08	.0000
.4235-08	.0000
.0000	.0000

X(5)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.8274+01

BODE GAIN = -.1168+01

ROOTS

REAL PART	IMAGINARY PART
.9329-01	.0000
-.1085+00	.1160+00
-.1085+00	-.1160+00
-.5865+01	.0000
-.2646-00	.1040+01
-.2646-00	-.1040+01
-.6961-00	.0000
.2794-08	.0000
-.4404-09	.0000
.0000	.0000

94

X(6)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN=   .3635-00

BODE GAIN =   .4697+02

ROOTS

REAL PART	IMAGINARY PART
-.3459-01	.2713-00
-.3459-01	-.2713-00
-.9177+01	.0000
-.2239+01	.2116+01
-.2239+01	-.2116+01
.2298+01	.0000
-.6783-00	.0000
-.1339-07	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3105+02

BODE GAIN =   .3015+04

ROOTS

REAL PART	IMAGINARY PART
.3576-07	.0000
-.5975-00	.0000
-.5325-01	.0000
-.1081+02	.0000
-.6439-01	.4339+01
-.6439-01	-.4339+01
-.2802-00	.1049+01
-.2802-00	-.1049+01
.0000	.0000
.0000	.0000

X(2)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.1341+02

BODE GAIN = .2485+03

ROOTS

REAL PART	IMAGINARY PART
-.2771-01	.0000
.6986-00	.8364+01
.6986-00	-.8364+01
.5760-00	.7034-00
.5760-00	-.7034-00
-.3838+01	.0000
-.2351-00	.0000
.1397-08	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.7339+02

BODE GAIN = -.2854+03

ROOTS

REAL PART	IMAGINARY PART
-.5657-01	.0000
.1900+02	.0000
-.3203-01	.1430-00
-.3203-01	-.1430-00
-.1117+02	.0000
-.2812-00	.1052+01
-.2812-00	-.1052+01
-.6752-08	.0000
.0000	.0000
.0000	.0000

96

X(4)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3419+02

BODE GAIN = -.9588-11

ROOTS

REAL PART	IMAGINARY PART
-.7133-06	.0000
.9713-06	.0000
-.1357-00	.1049+01
-.1357-00	-.1049+01
.9179-01	.0000
-.1229+01	.8263-00
-.1229+01	-.8263-00
-.1412-00	.0000
.1288-06	.0000
.0000	.0000

X(5)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .1440+02

BODE GAIN = .1127+00

ROOTS

REAL PART	IMAGINARY PART
.1198-01	.0000
-.1177+02	.0000
-.2829-00	.1055+01
-.2829-00	-.1055+01
-.6862-00	.0000
-.6750-01	.2777-01
-.6750-01	-.2777-01
.0000	.0000
-.1118-07	.0000
.0000	.0000

X(6)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.5370-00

BODE GAIN = -.4535+01

ROOTS

REAL PART	IMAGINARY PART
.1180+00	.0000
-.1488-00	.0000
-.1079+02	.0000
.2176-00	.3538+01
.2176-00	-.3538+01
-.1412-00	.5082-00
-.1412-00	-.5082-00
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .8080-00

BODE GAIN = .1767+03

ROOTS

REAL PART	IMAGINARY PART
.1787-06	.0000
-.1013+02	.0000
-.6255-00	.0000
-.1442-00	.2323-00
-.1442-00	-.2323-00
-.2745+01	.1628+01
-.2745+01	-.1628+01
.3562+01	.0000
.1887-08	.0000
.0000	.0000

98

X(2)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.1917+02

BODE GAIN = -.5864-00

ROOTS

REAL PART	IMAGINARY PART
.6813-04	.0000-0000
-.2687+02	.0000-0000
-.1069+02	.0000
-.1869+01	.0000
-.9544-00	.0000
-.3670-01	.2599-00
-.3670-01	-.2599-00
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.3575-01

BODE GAIN = -.5299+02

ROOTS

REAL PART	IMAGINARY PART
.1509-07	.0000-0000
.2961+03	.0000
-.2316-02	.2100-00
-.2316-02	-.2100-00
-.2120-00	.3255-00
-.2120-00	-.3255-00
-.1508+02	.0000
-.3917+01	.0000
.0000	.0000
.0000	.0000

X(4)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.9614-00

BODE GAIN = .3154+02

ROOTS

REAL PART	IMAGINARY PART
-.3663-01	.2612-00
-.3663-01	-.2612-00
-.4528+01	.0000
.4699+01	.0000
-.1791+01	.0000
-.9728-00	.0000
.0000	.0000
.1152-06	.0000
.5626-07	.0000
.0000	.0000

X(5)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.1525-01

BODE GAIN = .2485-00

ROOTS

REAL PART	IMAGINARY PART
-.5731-00	.2889-00
-.5731-00	-.2889-00
-.9789-01	.2122-00
-.9789-01	-.2122-00
.4768+02	.0000
-.5724+01	.0000
.2086-00	.0000
.2794-08	.0000
.0000	.0000
.0000	.0000

100

X(6)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .5142+01

BODE GAIN = -.9999+01

ROOTS

REAL PART	IMAGINARY PART
-.3739-01	.2629-00
-.3739-01	-.2629-00
-.1934-01	.3394-00
-.1934-01	-.3394-00
-.1051+02	.0000
-.1867+01	.0000

-.9553-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .2565+02

BODE GAIN = -.4076+02

ROOTS

REAL PART	IMAGINARY PART
.2336-07	.0000
-.1052+02	.0000
-.1237+00	.0000
-.4334-01	.0000
-.1326+01	.2847-00
-.1326+01	-.2847-00
-.2807-00	.1060+01
-.2807-00	-.1060+01
.0000	.0000
.0000	.0000

101

X(2)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .1118-01

BODE GAIN = -.1402+02

ROOTS

REAL PART	IMAGINARY PART
-.2808-01	.7763-01
-.2808-01	-.7763-01
.2426+03	.0000
.1550+02	.0000

-.3340+01	.0000
-.3693-00	.1008+01
-.3693-00	-.1008+01
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .1066+00

BODE GAIN = .4573+01

ROOTS

REAL PART	IMAGINARY PART
.1682-06	.0000
.2164+03	.0000
.1254-00	.9663-01
.1254-00	-.9683-01
-.4291-01	.0000
-.1198+02	.0000
-.2818-00	.1062+01
-.2818-00	-.1062+01
.0000	.0000
.0000	.0000

102

X(4)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   .8971-00

BODE GAIN =   .4788-00

ROOTS

REAL PART	IMAGINARY PART
-.1765-07	.0000
-.1407-06	.0000
.1142-06	.0000
-.3036-00	.1054+01
-.3036-00	-.1054+01
-.1284+01	.6620-00
-.1284+01	-.6620-00
.2278-00	.0000
.7335-01	.0000
-.4705-08	.0000

X(5)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   -.1960-00

BODE GAIN =   .3503-02

ROOTS

REAL PART	IMAGINARY PART
.4236-02	.0000
-.1279+02	.0000
-.2811-00	.1061+01
-.2811-00	-.1061+01
-.6956-00	.0000
.4988-00	.0000
-.6195-01	.0000
.1414-06	.0000
-.1213-07	.0000
.0000	.0000

103

X(6)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .2061-03

BODE GAIN = -.1410-00

ROOTS

REAL PART	IMAGINARY PART
.5128-01	.0000
.3745+03	.0000
.1125+00	.4420-00
.1125+00	-.4420-00
-.1113+02	.0000
-.4288-00	.1012+01
-.4288-00	-.1012+01
-.1048-06	.0000
.0000	.0000
.0000	.0000

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 9 SPEED=169.0 FT/SEC. H-DOT= 0.0 FT/SEC. GAMMA= 0.0 DEG.
GROSS WEIGHT=15600. SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.3933+02	.2112+01	-.1004+02	-.3461+03	.1461+04	-.7904+02
Y	.8632-00	-.7148+02	-.4676+01	-.1395+04	-.3105+03	.1280+04
Z	-.2410+02	-.3320+01	-.4259+03	-.1245+04	-.4227+03	.9934+03
L	-.5695+02	-.3575+03	-.3509+02	-.9066+05	.6977+04	-.6762+03
M	.1563+03	-.3236+02	-.2365+03	-.5995+04	-.1068+06	.2365+04
N	-.8039+02	.7339+03	-.1905+03	-.3108+04	.7712+04	-.4083+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	.9264-02	-.6105-04	-.2215-00	-.2378+02	.7664-02	-.1020+01
Y	-.7761-02	-.9309-04	.1805-03	.1601+01	-.2153+02	.6349-01
Z	.1223-02	-.2123-02	-.5049-01	-.6271+01	.3566+01	-.3094-00
L	-.8775-00	-.2072-01	.2004+02	.3046+04	-.1312+04	.1291+03
M	-.4194-00	-.3234-01	.9993+01	.1385+04	.3023+04	.5746+02
N	.2206-01	-.7512-03	-.5165-00	-.5898+02	-.3871+02	.6021+01

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.7084+04	-.5032+04	.1416+05	-.6918+03	-.1657+05
Y	-.4102+04	.1534+05	.5426+04	.1261+05	.9509-02
Z	-.1630+06	-.1223+04	.6735+05	.2551+02	-.7979+03
L	-.8114+05	.6822+06	.2523+06	.2707+05	-.1610+06
M	.5997+06	.2726+06	-.7985+06	.1530+04	.2150+05
N	.7634+05	-.3583+04	.5164+05	-.3844+06	.9744+02

THE INERTIA TENSOR

```
.1150+05     .0000    -.1841+04
.0000        .5000+05    .0000
-.1841+04     .0000     .5492+05
```

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

	U	V	W	P	Q	R
	.1688+03	-.0000	-.7160+01	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

```
.1344-00  -.9394-02   .5553-01   .3771-01  -.4237-01  -.2507-01
```

STABILITY AXIS SYSTEM EULER ANGLES- THETA= .8345-05 PHI -.2505-01
AIRCRAFT INERTIAL SPEED= .1690+03

DENOMINATOR CHARACTERISTIC
ROOTS

REAL PART	IMAGINARY PART
-.3692-01	.0000
-.1062+02	.0000
-.4014-00	.1510+01
-.4014-00	-.1510+01
-.4126-01	.1881-00
-.4126-01	-.1881-00
-.1580+01	.5560-00
-.1580+01	-.5560-00
.0000	.0000
.0000	.0000
.0000	.0000
.0000	.0000

NUMERATORS
(NOTE- NUMERATOR ROOTS LESS THAN 1.0E-7 TIMES THE
LARGEST NUMERATOR ROOT ARE NOT INCLUDED IN THE BODE GAIN).

X(1)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .1388+02

BODE GAIN =   -.4430+04

ROOTS

REAL PART	IMAGINARY PART
.3456-07	.0000
-.9212-00	.0000
-.4117-01	.0000
-.4148-00	.1492+01
-.4148-00	-.1492+01
-.1070+02	.0000
.4492-00	.5697+01
.4492-00	-.5697+01
.0000	.0000
.0000	.0000

106

X(2)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .9172+01

BODE GAIN = .4403+03

ROOTS

REAL PART	IMAGINARY PART
-.1004-06	.0000
.6410-01	.4604-00
.6410-01	-.4604-00
.3066-01	.0000

-.4942-00	.0000
-.1250+02	.1502+02
-.1250+02	-.1502+02
-.3823+01	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .3362+03

BODE GAIN = -.1197-02

ROOTS

REAL PART	IMAGINARY PART
.1340-04	.0000
-.1078+02	.0000
-.1619-00	.0000
-.2211-01	.0000
.7003-01	.0000
.4060+01	.0000
-.4114-00	.1499+01
-.4114-00	-.1499+01
.0000	.0000
.0000	.0000

107

X(4)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .1193+02

BODE GAIN = -.1569-03

ROOTS

REAL PART	IMAGINARY PART
-.4046-00	.0000
.5038-00	.0000
.7023-01	.9470-00
.7023-01	-.9470-00
-.1255+01	.1718+01
-.1255+01	-.1718+01
.1574-05	.0000
.2466-07	.0000
.0000	.0000
.2887-07	.0000

X(5)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.1215+02

BODE GAIN = -.4713-00

ROOTS

REAL PART	IMAGINARY PART
.2220-01	.0000
-.7029-01	.3768-01
-.7029-01	-.3768-01
-.1115+02	.0000
-.4098-00	.1507+01
-.4098-00	-.1507+01
-.1006+01	.0000
.1456-07	.0000
-.9313-07	.0000
.0000	.0000

108

X(6)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.9975-00

BODE GAIN = .1881+02

ROOTS

REAL PART	IMAGINARY PART
-.2210-00	.4607-00
-.2210-00	-.4607-00
-.4607-00	.0000
.3056-00	.3350-00
.3056-00	-.3350-00
-.1755+02	.0000
-.4327+01	.0000
.0000	.0000
-.6985-09	.0000
.0000	.0000

X(1)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .1425+02

BODE GAIN = -.2325+04

ROOTS

REAL PART	IMAGINARY PART
-.1089-06	.0000
-.7662-00	.0000
-.6498-01	.0000
-.9993+01	.0000
-.1284+01	.3532+01
-.1284+01	-.3532+01
-.3635-00	.1475+01
-.3635-00	-.1475+01
.0000	.0000
.0000	.0000

X(2)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.3156+02

BODE GAIN = .2163+04

ROOTS

REAL PART	IMAGINARY PART
-.6119-02	.1834-00
-.6119-02	-.1834-00
-.4083-00	.0000
.4978+01	.9134+01
.4978+01	-.9134+01
-.1759+01	.1221+01
-.1759+01	-.1221+01
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .3492+01

BODE GAIN = .2170+03

ROOTS

REAL PART	IMAGINARY PART
-.1526-01	.9454-01
-.1526-01	-.9454-01
-.1200+00	.0000
.3318+03	.0000
-.7140+01	.0000
-.3840-00	.1492+01
-.3840-00	-.1492+01
.0000	.0000
.0000	.0000
.0000	.0000

110

X(4)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.7926+02

BODE GAIN = .4878-09

ROOTS

REAL PART	IMAGINARY PART
.1413-05	.0000
-.1519-05	.0000
-.4542-00	.1476+01
-.4542-00	-.1476+01
-.3841-01	.2070-00
-.3841-01	-.2070-00
-.1603+01	.3632-00
-.1603+01	-.3632-00
.4098-07	.0000
.0000	.0000

X(5)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.8129+01

BODE GAIN = -.1058+01

ROOTS

REAL PART	IMAGINARY PART
.6390-01	.0000
-.8735-01	.8341-01
-.8735-01	-.8341-01
-.6393+01	.0000
-.3923-00	.1494+01
-.3923-00	-.1494+01
-.9113-00	.0000
-.1316-07	.0000
.1130-07	.0000
.0000	.0000

111

X(6)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.2501+01

BODE GAIN = .4221+02

ROOTS

REAL PART	IMAGINARY PART
.1820-07	.0000
.2579-06	.0000
-.4014-01	.2041-00
-.4014-01	-.2041-00
-.2171+01	.1483+01
-.2171+01	-.1483+01
.1674+01	.1799+01
.1674+01	-.1799+01
-.9310-00	.0000
.0000	.0000

X(1)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.2759+02

BODE GAIN = .5165+04

ROOTS

REAL PART	IMAGINARY PART
.7815-07	.0000
-.8120-00	.0000
-.3877-01	.0000
-.4024-00	.1499+01
-.4024-00	-.1499+01
-.1074+02	.0000
-.1551-00	.4764+01
-.1551-00	-.4784+01
.0000	.0000
.0000	.0000

112

X(2)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.1207+02

BODE GAIN = -.8300+02

ROOTS

REAL PART	IMAGINARY PART
.6749-02	.0000
.2166+02	.0000
.5549-00	.0000
-.2373-00	.0000
-.4680+01	.0000
.1629+01	.2225+01
.1629+01	-.2225+01
-.3562-07	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.1385+03

BODE GAIN = -.1574+03

ROOTS

REAL PART	IMAGINARY PART
-.2950-01	.5947-01
-.2950-01	-.5947-01
-.5244-01	.0000
.1617+02	.0000
-.1111+02	.0000
-.4032-00	.1504+01
-.4032-00	-.1504+01
.0000	.0000
.0000	.0000
.0000	.0000

X(4)=TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3281+02

BODE GAIN = .1170-15

ROOTS

REAL PART	IMAGINARY PART
-.2380-07	.0000
.4733-06	.0000
.1514-05	.0000
.3206-05	.0000
-.2433-00	.1447+01
-.2433-00	-.1447+01
-.1334+01	.1333+01
-.1334+01	-.1333+01
-.1761-00	.0000
.1146+00	.0000

X(5)=TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .1600+02

BODE GAIN = .2419-00

ROOTS

REAL PART	IMAGINARY PART
.1252-01	.0000
-.1163+02	.0000
-.4039-00	.1506+01
-.4039-00	-.1506+01
-.9100-00	.0000
-.6395-01	.2416-01
-.6395-01	-.2416-01
.0000	.0000
.2561-06	.0000
.0000	.0000

114

X(2)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.2603+02

BODE GAIN = .6202+02

ROOTS

REAL PART	IMAGINARY PART
-.4665-02	.0000
-.4477+02	.0000
-.1077+02	.0000
-.1579+01	.5755-0?
-.1579+01	-.5755-0?
-.4116-01	.1888-0?
-.4116-01	-.1898-0?
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.3733-01

BODE GAIN = -.3344+02

ROOTS

REAL PART	IMAGINARY PART
-.1345-01	.1416-07
-.1345-01	-.1416-0?
.1928+03	.0000
-.2088-00	.2899-0?
-.2088-00	-.2899-0?
-.2823+02	.0000
-.6351+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(6)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.2015+01

BODE GAIN = -.9655+01

ROOTS

REAL PART	IMAGINARY PART
.1240+00	.0000
-.1822-00	.0000
-.1985-00	.6045-00
-.1985-00	-.6045-00
-.6177+01	.0000
.4683-00	.2868+01
.4683-00	-.2868+01
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .1490+01

BODE GAIN = .2286+03

ROOTS

REAL PART	IMAGINARY PART
.2476-06	.0000
-.1053+02	.0000
-.1246+00	.1944-00
-.1246+00	-.1944-00
-.9741-00	.0000
-.2516+01	.1812+01
-.2516+01	-.1812+01
.2904+01	.0000
.0000	.0000
.0000	.0000

115

X(4)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN = -.1557+01

BODE GAIN = .7179-04

ROOTS

REAL PART	IMAGINARY PART
-.2555-07	.9103-08
-.2555-07	-.9103-08
.1603-05	.0000
-.6004+01	.0000
-.1551+01	.6033-00
-.1551+01	-.6033-00
.4572+01	.0000
-.4068-01	.1894-00
-.4068-01	-.1894-00
.0000	.0000

X(5)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.6990-01

BODE GAIN = .2145-00

ROOTS

REAL PART	IMAGINARY PART
-.6480-00	.3386-00
-.6480-00	-.3386-00
-.8655-01	.1731-00
-.8655-01	-.1731-00
.1113+02	.0000
-.7540+01	.0000
.1800-00	.0000
-.7451-08	.0000
.4435-07	.0000
.9313-09	.0000

117

X(6)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN=   .6950+01

BODE GAIN =   -.8562+01

ROOTS

REAL PART	IMAGINARY PART
-.4046-01	.1903-00
-.4046-01	-.1903-00
-.3819-01	.3255-00
-.3819-01	-.3255-00
-.1068+02	.0000
-.1579+01	.5762-00
-.1579+01	-.5762-00
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   .3411+02

BODE GAIN =   -.6390+02

ROOTS

REAL PART	IMAGINARY PART
-.7786-08	.0000
-.1063+02	.0000
-.4005-00	.1512+01
-.4005-00	-.1512+01
-.2645-01	.0000
-.1522+01	.7318-00
-.1522+01	-.7318-00
-.9518-01	.0000
.0000	.0000
.0000	.0000

118

X(2)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   .1477-01

BODE GAIN = -.3377+02

ROOTS

REAL PART	IMAGINARY PART
-.2417-01	.8547-01
-.2417-01	-.8547-01
.1038+04	.0000
.7510+01	.0000
-.3197+01	.0000
-.4642-00	.9707-00
-.4642-00	-.9707-00
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   .1620+01

BODE GAIN =   .7837-00

ROOTS

REAL PART	IMAGINARY PART
.1139-01	.0000
.2262+02	.0000
.2687-00	.0000
-.2256-01	.0000
-.1254+02	.0000
-.4103-00	.1513+01
-.4103-00	-.1513+01
-.1697-08	.0000
.0000	.0000
.0000	.0000

119

X(4)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .193^+^:

BODE GAIN = .^006-05

ROOTS

REAL PART	IMAGINARY PART
.5821-01	.1255-00
.5821-01	-.1255-00
-.4300-00	.1451+01
-.4300-00	-.1451+01
-.1502+01	.9182-0
-.1502+01	-.9182-00
.1522-05	.0000
-.5633-07	.0000
-.2142-07	.0000
.0000	.0000

X(5)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.167^P-00

BODE GAIN = .1202-01

ROOTS

REAL PART	IMAGINARY PART
.1005-01	.0000
-.1514+02	.0000
-.4072-00	.1514-00
-.4072-00	-.1514+00
-.9068-00	.0000
.3692-00	.0000
-.5088-01	.0000
.2263-07	.0000
-.7272-06	.0000
.0000	.0000

X(6)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .609A-01

BODE GAIN = -.4800-00

ROOTS

REAL PART	IMAGINARY PART
.7916-01	.1428-00
.7916-01	-.1428-00
.4974+01	.0000
.9808-00	.0000
-.4328+01	.0000
-.6891-00	.9577-00
-.6891-00	-.9577-00
.3493-07	.0000
.0000	.0000
.0000	.0000

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 10 SPEED= 9.6 FT/SEC. H-DOT= -9.6 FT/SEC. GAMMA=-90.0 DEG.
GROSS WEIGHT=15600.   SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.1035+03	-.1469+01	-.3507-00	.1054+04	.2779+01	-.1959+03
Y	-.2949+01	-.2206+02	.2302+01	.4388+03	-.3731+03	.1514+04
Z	-.1160+01	-.1755+01	-.5789+01	.9805+02	-.1569+04	-.4832+03
L	-.1032+03	.3336+03	.7244+01	-.1217+05	-.8920+03	-.1181+04
M	-.7856+02	-.6321+02	-.4838+03	.6409+04	-.8794+05	.1001+05
N	-.2806+02	.4281+03	-.0565+02	-.1152+04	-.1094+05	-.8655+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	.6702-03	.6339-04	-.2193-04	-.2676-01	.1518+01	-.2967-00
Y	-.9814-02	-.8471-03	.3777-03	.1390+01	-.2404+02	-.1540+01
Z	.1403-01	.2794-03	-.8380-04	-.4536-00	.1514+01	-.2406+02
L	-.1263-02	.8701-02	-.4591-02	.1863+02	-.1434+03	.1468+03
M	.1781-00	-.9041-02	.1673-01	-.1934+03	.2944+04	-.1422+04
N	.1123+00	.5952-02	-.1635-02	-.3257+02	.1428+04	.2960+04

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.1113+06	-.1069+04	-.6620+03	-.6002+03	.5480+02
Y	-.6650+04	.1904+05	.5364+04	.0933+04	.2367+01
Z	.6675+02	.5404+04	-.1908+05	.5136+01	.2504+04
L	.2684+06	-.3231+05	.3323+05	-.2698+06	-.8440+03
M	-.3058+04	.2738+06	-.6847+06	-.2355+05	.2575+04
N	-.3364+04	-.6855+06	-.2752+06	-.3691+04	-.3001+02

THE INERTIA TENSOR

$$
\begin{array}{ccc}
.5497+05 & .2900+03 & -.7388+03 \\
.2900+03 & .5002+05 & -.4310+02 \\
-.7388+03 & -.4310+02 & .1151+05
\end{array}
$$

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

	U	V	W	P	Q	R
	-.1631-00	-.5591-00	.9582+01	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.2286-00   .5642-03   -.5838-02   .1617-00   .1699-01   -.5828-01

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= .1572+01   PHI .0000
AIRCRAFT INERTIAL SPEED= .9600+01

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 11 SPEED= 33.8 FT/SEC,   H-DOT= -9.6 FT/SEC,   GAMMA=-16.5 DEG,
GROSS WEIGHT=15600.   SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.8079+02	.1432+01	-.2732+02	-.2874+03	.1559+04	.3199+03
Y	.5335+01	-.2851+02	-.8629-00	-.1402+04	-.3472+03	.9266+03
Z	-.1605+03	-.1380+01	-.1085+03	.4110+03	-.2843+03	.7961+03
L	-.1421+03	-.2762+03	.6715+01	-.7962+05	.9176+04	.1989+05
M	.3060+03	-.6649+02	-.5966+02	-.8533+04	-.8683+05	.4952+04
N	-.2144+03	.4310+03	-.3425+02	.1896+05	-.5168+04	-.2177+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.1494-01	-.6614-04	-.4810-01	-.2077+02	-.3065-00	.6435+01
Y	.1468-01	.1347-03	.4690-01	.6518-00	-.2580+02	-.2071-00
Z	.1067-01	-.9861-03	.3429-01	.1481+02	.1045+01	-.4501+01
L	.1112+01	.4930-03	.3603+01	.2700+04	-.1347+04	-.8354+03
M	.6547-00	-.2867-01	.2105+01	.1356+04	.2963+04	-.4179+03
N	-.5714-00	-.2485-02	-.1194+01	-.8763+03	.4238+03	.2804+03

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.3808+05	-.4790+04	.1737+05	-.1846+03	-.6235+04
Y	-.6861+03	.1811+05	.5607+04	.7754+04	.7283-03
Z	-.9802+05	.3381+04	-.2966+04	.2297+02	.1967+04
L	.4812+05	.6494+06	.2615+06	-.6307+05	-.1516+04
M	.7875+05	.2754+06	-.6850+06	-.4741+04	.6710+04
N	.2194+06	-.2114+06	-.3157+05	-.2270+06	-.4283+03

THE INERTIA TENSOR

```
     .1532+05   -.3822-05    .1231+05
    -.3822-05    .5000+05    .1357-05
     .1231+05    .1357-05    .5118+05
```


TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.3228+02	-.3725-08	.1602+02	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.2049-00   -.1744-02   .1020-01   .1254-00   .1254-01   -.4383-01

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.2881-00   PHI -.4571-01
AIRCRAFT INERTIAL SPEED= .3380+02

123

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 12 SPEED= 67.8 FT/SEC. H-DOT= -9.6 FT/SEC. GAMMA= -8.05DEG.
GROSS WEIGHT=15600. SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.6395+02	.1807+01	-.4495+02	-.2853+03	.1855+04	.9453+02
Y	.9959-01	-.3479+02	-.1721+01	-.1666+04	-.2405+03	.9718+03
Z	-.1103+03	-.1275+01	-.2497+03	-.1357+03	-.2308+03	.8893+03
L	-.9118+02	-.2510+03	-.3882+02	-.8715+05	.9451+04	.9968+04
M	.1801+03	-.4532+02	-.1927+03	-.8416+04	-.9408+05	.3708+04
N	-.1937+03	.4994+03	-.2070+03	.1086+05	.4188+03	-.2385+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.1787-01	-.1056-04	-.1143+00	-.2801+02	.1119+01	.4365+01
Y	.1239-01	-.1266-03	.8001-01	-.8424-00	-.2923+02	.1300-00
Z	.4514-02	-.8449-03	.2886-01	.6153+01	.9143-00	-.9372-00
L	.1234+01	.1298-02	.7919+01	.2905+04	-.1367+04	-.4529+03
M	.5836-00	-.2551-01	.4374+01	.1387+04	.2980+04	-.2161+03
N	-.2391-00	.4422-03	-.1534+01	-.5432+03	.2294+03	.9331+02

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.1432+05	-.6019+04	.1752+05	-.1992+03	-.9673+04
Y	-.1663+04	.1667+05	.6249+04	.7283+04	.3017-02
Z	-.1180+06	.1338+04	.1650+05	.1790+02	.1564+04
L	-.1878+05	.6690+06	.2716+06	-.2778+05	-.3954+04
M	.2217+06	.2763+06	-.6970+06	-.1792+04	.1020+05
N	.1245+06	-.1220+06	-.2564+05	-.2197+06	-.3730+03

THE INERTIA TENSOR

$$\begin{matrix} .1254+05 & -.2058-05 & .6637+04 \\ -.2058-05 & .5000+05 & .3647-06 \\ .6637+04 & .3647-06 & .5396+05 \end{matrix}$$

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.6699+02	-.3725-08	.1047+02	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.1648-00   -.2967-02   .1915-01   .5098-01   .1295-01   -.2007-01

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.1421-00   PHI -.2027-01
AIRCRAFT INERTIAL SPEED= .6730+02

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 13 SPEED=101.5 FT/SEC.   H-DOT= -9.6 FT/SEC.   GAMMA= -5.41DEG.
GROSS WEIGHT=15600.   SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.4197+02	.1716+01	-.3752+02	-.3163+03	.1716+04	.6598+02
Y	.7185-01	-.4996+02	-.3083+01	-.1566+04	-.2284+03	.1054+04
Z	-.7087+02	-.1215+01	-.3213+03	-.5238+03	-.2479+03	.9326+03
L	-.6465+02	-.2552+03	-.3674+02	-.8812+05	.8800+04	.5133+04
M	.1541+03	-.3582+02	-.1628+03	-.7736+04	-.9713+05	.3055+04
N	-.1057+03	.5966+03	-.2418+03	.4130+04	.3953+04	-.2918+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.1283-01	-.1780-03	-.1720-00	-.2792+02	.1094+01	.2033+01
Y	.7451-02	-.2166-03	.1034+00	-.4923-00	-.2670+02	.3637-01
Z	.4393-03	-.8071-03	.5693-02	-.3619-00	.2002+01	.2462-01
L	.8756-00	-.2062-02	.1201+02	.2983+04	-.1343+04	-.2187+03
M	.4874-00	-.1563-01	.6502+01	.1377+04	.2998+04	-.1013+03
N	-.1095+00	.2679-02	-.1508+01	-.3542+03	.1176+03	.3439+02

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.1676+05	-.5890+04	.1812+05	-.2804+03	-.1230+05
Y	-.2558+04	.1543+05	.5909+04	.9225+04	.4737-02
Z	-.1379+06	-.2411+02	.3471+05	.1834+02	.9504+03
L	-.4820+05	.6722+06	.2668+06	-.1247+05	-.7185+04
M	.3323+06	.2724+06	-.7134+06	-.8973+03	.1225+05
N	.3067+05	-.7241+05	.1229+05	-.2804+06	-.2124+03

THE INERTIA TENSOR

```
.1173+05   -.2107-05   .3181+04
-.2107-05   .5000+05   .1751-06
.3181+04   .1751-06   .5477+05
```

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.1012+03	-.5588-08	.7441+01	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.1572-00   -.3394-02   .2530-01   .3443-01   -.2135-01   -.1637-01

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.9474-01   PHI -.1644-01
AIRCRAFT INERTIAL SPEED= .1015+03

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-8 DERIVATIVES
CASE 14 SPEED=169.0 FT/SEC.   H-DOT= -9.6 FT/SEC.   GAMMA= -3.25DEG.
GROSS WEIGHT=15600, SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.3026+02	.1525+01	-.1871+02	-.3528+03	.1318+04	.9991+01
Y	.3373-00	-.6991+02	-.4841+01	-.1211+04	-.2281+03	.1339+04
Z	-.5078+02	-.1402+01	-.4275+03	-.1133+04	-.5014+03	.8842+03
L	-.5286+02	-.2616+03	-.2977+02	-.8756+05	.6966+04	.2025+04
M	.6579+02	-.2202+02	-.2242+03	-.5310+04	-.1038+06	.2269+04
N	-.5775+02	.7445+03	-.2033+03	-.1312+04	.7714+04	-.4034+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.5139-03	-.1213-03	-.2311-00	-.2217+02	.4567-00	.2245-01
Y	-.5342-04	-.3091-03	.1278-00	.8441-00	-.1960+02	-.2550-02
Z	-.1898-02	-.2675-02	-.4115-01	-.5039+01	.4327+01	-.2300-01
L	.1484-01	-.9680-02	.1957+02	.3054+04	-.1264+04	-.4409+01
M	.1627-01	-.2434-01	.1005+02	.1339+04	.3035+04	-.2884+01
N	-.5113-03	.2935-02	-.1400+01	-.1981+03	.1970+02	.8711+01

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.1628+05	-.4638+04	.1601+05	-.5347+03	-.1655+05
Y	-.3921+04	.1311+05	.5000+04	.1260+05	.7933-02
Z	-.1650+06	-.9644+03	.6752+05	.2260+02	.1312+02
L	-.7425+05	.6663+06	.2455+06	.1037+05	-.1600+05
M	.5847+06	.2638+06	-.7826+06	.6736+03	.1411+05
N	.3471+05	-.2922+05	.4484+05	-.3842+06	-.2732+01

THE INERTIA TENSOR

.1150+05	-.4243-06	.6538+02
-.4243-06	.5000+05	.7206-09
.6538+02	.7206-09	.5500+05

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.1690+03	-.1863-08	.2540-00	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.1570-00   -.4032-02   .3558-01   .2631-01   -.5533-01   -.1706-01

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.5683-01   PHI -.1706-01
AIRCRAFT INERTIAL SPEED= .1690+03

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 15 SPEED= 19.2 FT/SEC.   H-DOT=-19.2 FT/SEC.   GAMMA=-90.0 DEG.
GROSS WEIGHT=15600.   SEA LEVEL, DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.8870+02	.3770+01	-.2216+01	.1029+04	-.3486+02	-.1879+03
Y	.2292-00	-.2128+02	.2596+01	.4297+03	-.2773+03	.1575+04
Z	-.1976+01	-.2131+01	-.7394+01	.9108+02	-.1619+04	-.4410+03
L	-.1727+03	.3356+03	-.1586+02	-.1201+05	-.2919+04	-.1518+04
M	-.9954+02	-.5989+02	-.4954+03	.6044+04	-.8870+05	.1034+05
N	-.2571+02	.4126+03	-.8350+02	-.1198+04	-.1125+05	-.8649+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	.1870-02	.1220-03	-.3818-04	.1661-02	.1086+01	-.1913-00
Y	-.9935-02	-.4853-03	.1955-03	.1330+01	-.2497+02	-.9922-00
Z	.1513-01	.1269-03	-.2853-03	-.4308-00	.9960-00	-.2498+02
L	-.2522-02	.1762-02	.2191-03	.1688+02	-.1276+03	.1413+03
M	.1685-00	.1549-01	-.8926-02	-.1788+03	.2941+04	-.1423+04
N	.1172+00	.1718-01	-.1355-01	-.2504+02	.1428+04	.2956+04

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.1119+06	-.8415+03	-.5022+03	-.5907+03	.8869+02
Y	-.6071+04	.1861+05	.5522+04	.8516+04	.3290+01
Z	.2119+03	.5518+04	-.1865+05	.9227+01	.3779+04
L	.2505+06	-.3068+05	.2912+05	-.2573+06	-.1686+04
M	-.5571+04	.2738+06	-.6783+06	-.2271+05	.4059+04
N	-.4513+04	-.6790+06	-.2749+06	-.3844+04	.4860+02

THE INERTIA TENSOR

.5497+05	.2650+03	-.7452+03
.2650+03	.5001+05	-.3970+02
-.7452+03	-.3970+02	.1151+05

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
-.3289-00	-.1022+01	.1917+02	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.2204-00	.6522-03	-.6575-02	.1486-00	.1713-01	-.5324-01

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= .1572+01   PHI   .0000
AIRCRAFT INERTIAL SPEED= .1920+02

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   NOSTAB-B DERIVATIVES
CASE 16 SPEED= 33.8 FT/SEC.   H-DOT=-19.2 FT/SEC.   GAMMA=-33.5 DEG.
GROSS WEIGHT=15600.   SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.1416+03	.9202-00	.2667+01	.7652+02	.1342+04	.5120+03
Y	.2965+01	-.2704+02	-.9930-01	-.1092+04	-.2698+03	.1326+04
Z	-.1560+03	-.1802+01	-.2699+02	.6640+03	-.9406+03	.4283+03
L	-.2050+03	-.1205+03	.3633+02	-.6200+05	.6457+04	.3356+05
M	.2547+03	-.6472+02	-.2293+03	-.6821+04	-.8859+05	.7515+04
N	-.1623+03	.4820+03	-.1795+02	.3291+05	-.9328+04	-.3862+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.1769-01	-.1554-02	-.2230-01	-.1140+02	.2742-00	.8135+01
Y	.2210-01	-.7102-04	.3132-01	.1868-00	-.2652+02	-.1321-00
Z	.2685-01	-.3182-02	.4162-01	.2034+02	.6615-00	-.1438+02
L	.1564+01	.6923-02	.2191+01	.1955+04	-.1147+04	-.1387+04
M	.1111+01	-.2533-01	.1562+01	.1158+04	.2959+04	-.8215+03
N	-.1145+01	-.2689-02	-.1610+01	-.1421+04	.8250+03	.1020+04

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.5764+05	-.3061+04	.1310+05	-.1626+03	-.5191+04
Y	-.6008+03	.1771+05	.5696+04	.7516+04	.1571-02
Z	-.4231+05	.5403+04	-.1089+05	.2632+02	.3770+04
L	.1091+06	.5464+06	.2220+06	-.1266+06	-.1840+04
M	.6423+05	.2754+06	-.6790+06	-.5695+04	.7502+04
N	.1817+06	-.3992+06	-.1603+06	-.1899+06	-.7201+03

THE INERTIA TENSOR

$$\begin{array}{ccc} .2614+05 & -.5260-05 & .2055+05 \\ -.5260-05 & .5000+05 & .4531-05 \\ .2055+05 & .4531-05 & .4036+05 \end{array}$$

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.2753+02	-.7451-06	.1961+02	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.1978-00 -.1298-02   .7760-02   .1182+00   .1417-01 -.3980-01

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.6042-00   PHI -.4836-01
AIRCRAFT INERTIAL SPEED= .3380+02

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 17 SPEED= 67.8 FT/SEC.   W-DOT=-19.2 FT/SEC.   GAMMA=-16.45DEG.
GROSS WEIGHT=15400.   SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.8230+02	.1577+01	-.6925+02	-.2211+03	.1767+04	.2363+03
Y	-.3172-00	-.3724+02	-.1466+01	-.1537+04	-.1773+03	.1168+04
Z	-.1394+03	-.9735-00	-.2124+03	-.9251+01	-.1847+03	.7808+03
L	-.1124+03	-.1482+03	-.6600+02	-.8193+05	.9417+04	.1781+05
M	.1329+03	-.3807+02	.8877+02	-.7822+04	-.8505+05	.4747+04
N	-.1899+03	.5136+03	-.2221+03	.1008+05	-.5959+03	-.2692+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.3200-01	.1756-03	-.1100+00	-.2654+02	.1746+01	.7763+01
Y	.1787-01	.3504-04	.6091-01	-.1405+01	-.2950+02	.4106-00
Z	.1480-01	.1007-02	.4504-01	.9911+01	.6084-00	-.2882+01
L	.2076+01	.9817-03	.7099+01	.2732+04	-.1309+04	-.7975+03
M	.1244+01	-.6827-02	.4216+01	.1330+04	.2984+04	-.3890+03
N	-.6925-00	-.1074-02	-.2363+01	-.8914+03	.4018+03	.2694+03

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.3268+05	-.5805+04	.1699+09	-.1453+03	-.9349+04
Y	-.1618+04	.1552+05	.6237+04	.7058+04	-.7713-03
Z	-.1144+06	.2193+04	.1374+05	.1545+02	.2845+04
L	-.1162+05	.6402+06	.2645+06	-.5410+05	-.4092+04
M	.2070+06	.2739+06	-.6865+06	-.1658+04	.1147+05
N	.9157+05	-.2043+06	-.5810+05	-.2074+06	-.6603+03

THE INERTIA TENSOR

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          .1493+05   -.1927-05    .1173+05
         -.1927-05    .5000+05    .6446-06
          .1173+05    .6446-06    .5157+05
```

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

	U	V	W	P	Q	R
	.6507+02	-.3725-08	.1905+02	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

     .1463-00 -.1291-02   .1326-01   .3274-01 -.2301-02 -.1166-01

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.2871-00   PHI -.1216-01
AIRCRAFT INERTIAL SPEED= .6780+02

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LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 18 SPEED=101.5 FT/SEC.   W-DOT=-19.2 FT/SEC.   GAMMA=-10.9 DEG.
GROSS WEIGHT=15600.   SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.4934+02	.1497+01	-.5419+02	-.2913+03	.1710+04	.1765+03
Y	-.8717-00	-.4822+02	-.3096+01	-.1422+04	-.1552+03	.1174+04
Z	-.1053+03	-.2159-00	-.3107+03	-.4065+03	-.4331+03	.8216+03
L	-.6694+02	-.1507+03	-.6210+02	-.8464+05	.8984+04	.1047+05
M	.6734+02	-.2634+02	-.1735+03	-.7153+04	-.9528+05	.3515+04
N	-.9992+02	.6085+03	-.2742+03	.8588+04	.3794+04	-.3000+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.2948-01	-.2777-03	-.1784-00	-.2698+02	.1866+01	.4408+01
Y	.1156-01	-.1526-03	.7148-01	-.1141+01	-.2609+02	.1863-00
Z	.3077-02	-.1275-02	.2381-01	.2131+01	.2157+01	-.3497-00
L	.1848+01	-.6724-02	.1135+02	.2915+04	-.1296+04	-.4758+03
M	.1067+01	-.6388-02	.6472+01	.1332+04	.3006+04	-.2180+03
N	-.4063-00	.2660-02	-.2498+01	-.6210+03	.2339+03	.1100+03

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.3253+05	-.5704+04	.2046+05	-.1982+03	-.1222+05
Y	-.2506+04	.1374+05	.5736+04	.9162+04	.1781-02
Z	-.1366+06	.5173+03	.3299+05	.1442+02	.2116+04
L	-.4770+05	.6526+06	.2628+06	-.3689+05	-.7356+04
M	.3220+04	.2674+06	-.7003+06	-.9590+03	.1443+05
N	.3863+05	-.1282+06	-.6355+04	-.2758+06	-.4498+03

THE INERTIA TENSOR

.1264+05	-.2057-05	.6935+04
-.2057-05	.5000+05	.3818-06
.6935+04	.3818-06	.5386+05

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.1002+03	-.5588-08	.1640+02	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.1337-00   -.1087-03   .1375-01   .1961-01   -.2807-01   -.7701-02

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.1903-00   PHI -.7839-02
AIRCRAFT INERTIAL SPEED= .1015+03

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LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 19 SPEED=169.0 FT/SEC.   W-DOT=-19.2 FT/SEC.   GAMMA= -6.52DEG.
GROSS WEIGHT=15600.   SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.4017+02	.1241+01	-.3062+02	-.3376+03	.1228+74	.8694+02
Y	-.2215-00	-.6768+02	-.4997+01	-.9938+03	-.1197+03	.1394+04
Z	-.8511+02	.1054+01	-.4281+03	-.1004+04	-.6073+03	.7251+03
L	-.4687+02	-.1455+03	-.4052+02	-.8337+05	.6942+04	.5077+04
M	-.4109+02	-.1106+02	-.2006+03	-.4548+04	-.1003+06	.2122+04
N	-.4269+02	.7503+03	-.2388+03	.7209+03	.7893+04	-.4015+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.1411-01	-.1844-03	-.2432-00	-.2021+02	.1264+01	.1147+01
Y	.3280-02	-.3788-03	.6231-01	-.1999-00	-.1742+02	.9615-02
Z	-.2715-02	-.1402-02	-.3166-01	-.3380+01	.5312+01	.1756-00
L	.1062+01	-.1322-01	.1886+02	.3046+04	-.1201+04	-.1736+03
M	.5706-00	-.1239-01	.9935+01	.1277+04	.3051+04	-.7354+02
N	-.1392-00	.4194-02	-.2465+01	-.3756+03	.8937+02	.2991+02

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.2839+05	-.4178+04	.1852+05	-.3869+03	-.1653+05
Y	-.3682+04	.1034+05	.4517+04	.1259+05	.4008-02
Z	-.1668+06	-.6027+03	.6743+05	.1806+02	.1039+04
L	-.7138+05	.6474+06	.2369+06	-.1080+05	-.1604+05
M	.5756+06	.2535+06	-.7647+06	.2198+02	.1745+05
N	-.2068+05	-.6020+05	.3837+05	-.3829+06	-.1326+03

THE INERTIA TENSOR

$$
\begin{array}{ccc}
.1164+05 & -.8455-06 & .2479+04 \\
-.8455-06 & .5000+05 & .5465-07 \\
.2479+04 & .5465-07 & .5486+05
\end{array}
$$

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.1687+03	-.3725-08	.9647+01	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

    .1229+00   .2606-02   .1053-01   .1559-01   -.5674-01   -.8892-02

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.1139+00   PHI -.8936-02
AIRCRAFT INERTIAL SPEED= .1690+03

131

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 20 SPEED= 33.8 FT/SEC.   H-DOT=-28.8 FT/SEC.   GAMMA=-58.3 DEG.
GROSS WEIGHT=15600.   SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.1337+03	.3086-00	.7174+02	.6582+03	.7098+03	.4258+03
Y	.3495+01	-.2534+02	.1943+01	-.4827+03	-.2097+03	.1655+04
Z	-.6700+02	-.1909+01	.1552+02	.6370+03	-.1538+04	-.8672+02
L	-.2195+03	.9020+02	.4481+02	-.3239+05	.2876+03	.3149+05
M	.1321+03	-.6836+02	-.3434+03	-.3568+04	-.8914+05	.1010+05
N	-.8397+02	.4997+03	-.5301+02	.3102+05	-.1299+05	-.6791+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.2287-02	-.4195-04	-.1325-02	-.7477-00	.4427-00	.1363+01
Y	.1755-01	-.1761-04	.1025-01	.8093-01	-.2657+02	-.1154+00
Z	.3709-01	-.9187-03	.2161-01	.1467+02	.3739-00	-.2503+02
L	.8555-00	.4482-02	.4990-00	.7439+03	-.7109+03	-.1264+04
M	.1105+01	-.1697-01	.6450-00	.7214+03	.2949+04	-.1234+04
N	-.1500+01	.1667-02	-.8768-00	-.1289+04	.1232+04	.2221+04

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.9099+05	-.3645+03	.4768+04	-.1674+03	-.3094+04
Y	-.4425+03	.1782+05	.5708+04	.7694+04	.3659-03
Z	-.5436+05	.6285+04	-.1713+05	.2056+02	.5454+04
L	.1812+06	.3328+06	.1353+06	-.1977+06	-.2536+04
M	.3285+05	.2758+06	-.6746+06	-.7805+04	.7733+04
N	.1186+06	-.5838+06	-.2387+06	-.1239+06	-.6062+03

THE INERTIA TENSOR

.4398+05	-.7962-05	.1892+05
-.7962-05	.5000+05	.2502-04
.1892+05	.2502-04	.2252+05

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.1701+02	-.4470-07	.2921+02	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.2028-00	-.2950-03	.2579-02	.1237+00	.2194-01	-.4239-01

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.1020+01   PHI -.8105-01
AIRCRAFT INERTIAL SPEED= .3380+02

DENOMINATOR CHARACTERISTIC
ROOTS

REAL PART	IMAGINARY PART
-.1695-00	.1004+00
-.1695-00	-.1004+00
-.9783+01	.0000
-.1898+01	.0000
-.1526-00	.4775-00
-.1526-00	-.4775-00
-.3251-01	.3680-00
-.3251-01	-.3680-00
.0000	.0000
.0000	.0000
.0000	.0000
.0000	.0000

NUMERATORS
(NOTE- NUMERATOR ROOTS LESS THAN 1.0E-7 TIMES THE
LARGEST NUMERATOR ROOT ARE NOT INCLUDED IN THE BODE GAIN).

X(1)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .1878+03

BODE GAIN = -.3712+03

ROOTS

REAL PART	IMAGINARY PART
-.3593-07	.0000
-.9783+01	.0000
-.1674+01	.0000
-.1448-00	.5119-00
-.1448-00	-.5119-00
-.7411-01	.3632-00
-.7411-01	-.3632-00
-.6652-01	.0000
.0000	.0000
.0000	.0000

133

X(2)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .9584-00

BODE GAIN =   .1883+03

ROOTS

REAL	IMAGINARY
PART	PART
.6490-01	.0000
-.1120+03	.0000
-.6253+01	.0000
-.1904+01	.0000
-.4545-01	.3763-00
-.4546-01	-.3763-00
-.3908-00	.0000
.4221-07	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .1123+03

BODE GAIN =   .3790+03

ROOTS

REAL	IMAGINARY
PART	PART
-.1048+00	.2517-00
-.1048+00	-.2517-00
-.9810+01	.0000
-.1837+01	.0000
-.1898-00	.4548-00
-.1898-00	-.4548-00
.2565-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

134

X(4)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.2654+01

BODE GAIN = .2260+02

ROOTS

REAL PART	IMAGINARY PART
-.1021+00	.3593-00
-.1021+00	-.3593-00
-.3144-01	.3930-00
-.3144-01	-.3930-00
-.1276+02	.0000
-.1859+01	.0000
-.4089-00	.0000
.1118-07	.0000
.1551-06	.0000
.9486-08	.0000

X(5)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.6475-00

BODE GAIN = -.1123+01

ROOTS

REAL PART	IMAGINARY PART
-.1931-00	.2840-00
-.1931-00	-.2840-00
-.2574-00	.3828-00
-.2574-00	-.3828-00
-.1115+02	.0000
-.6488-00	.0000
.2362-00	.0000
-.2461-08	.0000
.0000	.0000
.0000	.0000

135

X(6)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.3256+01

BODE GAIN = .1383+02

ROOTS

REAL PART	IMAGINARY PART
-.6236-01	.3712-00
-.6236-01	-.3712-00
.2135-01	.4009-00
.2135-01	-.4009-00
-.5659+01	.0000
-.1976+01	.0000
-.4109-00	.0000
-.3492-09	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .9929-00

BODE GAIN = .8523+03

ROOTS

REAL PART	IMAGINARY PART
-.1954-02	.4776-00
-.1954-02	-.4776-00
-.3446-00	.0000
-.9355+01	.0000
.2250+01	.1366+01
.2250+01	-.1366+01
.4128+01	.0000
-.1490-07	.0000
.0000	.0000
.0000	.0000

136

X(2)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.3635+02

BODE GAIN = .2041+04

ROOTS

REAL PART	IMAGINARY PART
-.2545-01	.3631-00
-.2545-01	-.3631-00
-.2579-00	.1008+00
-.2579-00	-.1008+00
-.6355+02	.0000
-.1909+01	.0000
-.1127+01	.0000
-.6712-07	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.1761+02

BODE GAIN = .1334+04

ROOTS

REAL PART	IMAGINARY PART
-.3457-00	.1446-00
-.3457-00	-.1448-00
-.2239+02	.0000
-.3690+01	.0000
-.3342-01	.4833-00
-.3342-01	-.4833-00
-.6519-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

137

X(4)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.3878+02

BODE GAIN = .2967+02

ROOTS

REAL PART	IMAGINARY PART
-.1911-00	.0000
-.1988+01	.0000
-.5835-00	.0000
-.3700-01	.3755-00
-.3700-01	-.3755-00
.1648-00	.7563-00
.1648-00	-.7563-00
.0000	.0000
.0000	.0000
.0000	.0000

X(5)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.8210+01

BODE GAIN = -.1475+01

ROOTS

REAL PART	IMAGINARY PART
-.1893-00	.0000
-.4971+01	.0000
-.5550-01	.4754-00
-.5550-01	-.4754-00
-.2392-00	.2180-00
-.2392-00	-.2180-00
.1967-00	.0000
-.3439-08	.0000
.0000	.0000
.0000	.0000

138

X(6)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .6687+02

BODE GAIN = .1816+32

ROOTS

REAL PART	IMAGINARY PART
-.1957-00	.0003
-.1953+01	.0000
-.3655-00	.4272-00
-.3655-00	-.4272-00
-.2931-01	.3734-00
-.2931-01	-.3734-00
.3987-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.9719+01

BODE GAIN = -.7913+03

ROOTS

REAL PART	IMAGINARY PART
-.1115+00	.0000
-.1497-00	.4747-00
-.1497-00	-.4747-00
.3642-00	.0000
-.9819+01	.0000
.2005-00	.4388+01
.2005-00	-.4388+01
.0000	.0000
.0000	.0000
.0000	.0000

139

X(2)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN=   -.1252+02

BODE GAIN =   .5460+03

ROOTS

REAL PART	IMAGINARY PART
.2313-06	.0000
-.8056+02	.0000
-.1827+01	.0000
-.8763-00	.0000
-.1110+00	.4952-00
-.1110+00	-.4952-00
.6643-02	.1800-00
.6643-02	-.1800-00
.0000	.0000
.0000	.0000

X(3)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN=   .3331+02

BODE GAIN =   -.1955+04

ROOTS

REAL PART	IMAGINARY PART
-.1362-00	.0000
-.1150+02	.4061+01
-.1150+02	-.4061+01
-.1502-00	.4747-00
-.1502-00	-.4747-00
-.5361-00	.3689-01
-.5361-00	-.3689-01
.0000	.0000
.0000	.0000
.0000	.0000

X(4)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.1721+02

BODE GAIN = .7371-12

ROOTS

REAL PART	IMAGINARY PART
.1885-06	.1528-07
.1885-06	-.1528-07
- .9631-00	.9424-00
-.9631-00	-.9424-00
-.1560-00	.4310-00
-.1560-00	-.4310-00
-.1054+01	.0000
.1583-00	.3256-00
.1583-00	-.3256-00
-.3725-08	.0000

X(5)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .1329+02

BODE GAIN = -.1025+01

ROOTS

REAL PART	IMAGINARY PART
-.1308-07	.0000
-.1125+02	.0000
-.1513-00	.4751-00
-.1513-00	-.4751-00
-.2090-00	.1421-00
-.2090-00	-.1421-00
.3776-01	.9650-01
.3776-01	-.9650-01
.0000	.0000
.0000	.0000

X(6)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .2970+02

BODE GAIN = .1262+02

ROOTS

REAL PART	IMAGINARY PART
.7802-01	.3274-00
.7802-01	-.3274-00
-.1259-00	.4641-00
-.1259-00	-.4641-00
-.1328+01	.0000
-.7182-00	.0000
.4201-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .3489-00

BODE GAIN = -.2618+03

ROOTS

REAL PART	IMAGINARY PART
-.1021+00	.3532-00
-.1021+00	-.3532-00
.2943-00	.5408-00
.2943-00	-.5408-00
-.2121+02	.0000
-.9816+01	.0000
-.1739+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

142

X(2)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.1589+02

BODE GAIN = -.8203+02

ROOTS

REAL PART	IMAGINARY PART
.4668-01	.00C0
-.1206+02	.0000
-.3920+01	.0000
-.1899+01	.C000
-.3839-01	.3706-00
-.3839-01	-.3706-00
-.2194-00	.0000
-.1743-06	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.9593-01

BODE GAIN = -.3633+03

ROOTS

REAL PART	IMAGINARY PART
-.1014+00	.3367-00
-.1014+00	-.3367-00
-.6689-00	.2240-00
-.6689-00	-.2240-00
.9159+02	.0000
-.1185+02	.00C0
-.1402+01	.0000
.4008-07	.0000
.0000	.0000
.0000	.0000

143

X(4)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN=   .3208+01

BODE GAIN =   -.1248+02

ROOTS

REAL PART	IMAGINARY PART
-.1810-07	.0000
-.1129+02	.0000
-.1892+01	.0000
-.8834-01	.3605-00
-.8834-01	-.3605-00
-.3376-01	.3816-00
-.3376-01	-.3816-00
-.2228-00	.0000
-.2204-10	.0000
.0000	.0000

X(5)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN=   .1385-00

BODE GAIN =   .6207-00

ROOTS

REAL PART	IMAGINARY PART
-.2542-00	.0000
-.1396+02	.0000
-.8086-00	.2648-00
-.8086-00	-.2648-00
-.9747-01	.3296-00
-.9747-01	-.3296-00
.3651-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

144

X(6)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .2919+01

BODE GAIN = -.7642+01

ROOTS

REAL PART	IMAGINARY PART
-.4691-01	.3671-00
-.4691-01	-.3671-00
.1754-01	.3973-00
.1754-01	-.3973-00
-.6999+01	.0000
-.1909+01	.0000
-.2236-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .6386+01

BODE GAIN = .8866+01

ROOTS

REAL PART	IMAGINARY PART
-.9012-01	.0000
-.9783+01	.0000
-.1541+01	.0000
-.1412-00	.4715-00
-.1412-00	-.4715-00
-.3949-00	.0000
.2641-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

145

X(2)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .8849-02

BODE GAIN = -.6037-00

ROOTS

REAL PART	IMAGINARY PART
.1371-05	.0000
-.2728+03	.0000
-.1837+01	.0000
-.2704-00	.0000
.9904-02	.0000
.5090+01	.0000
.6253-01	.4930-00
.6253-01	-.4930-00
.0000	.0000
.0000	.0000

X(3)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.1125+02

BODE GAIN = .2039+02

ROOTS

REAL PART	IMAGINARY PART
-.9399-01	.0000
-.9751+01	.0000
-.2288+01	.0000
-.1436-00	.4739-00
-.1436-00	-.4739-00
-.2568-00	.1453-00
-.2568-00	-.1453-00
.0000	.0000
.0000	.0000
.0000	.0000

146

X(4)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .9698-01

BODE GAIN = -.2760-00

ROOTS

REAL PART	IMAGINARY PART
-.3084-07	.0000
-.1102+00	.3985-00
-.1102+00	-.3985-00
-.2791-00	.0000
.3063-00	.2953-00
.3063-00	-.2953-00
-.2139+01	.1888+01
-.2139+01	-.1888+01
.0000	.0000
.0000	.0000

X(5)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.1609-00

BODE GAIN = .1372-01

ROOTS

REAL PART	IMAGINARY PART
.2929-01	.0000
-.1029+02	.0000
-.1872-00	.1098+00
-.1872-00	-.1098+00
-.1425-00	.4763-00
-.1425-00	-.4763-00
.6008-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

147

X(6)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.7643-01

BODE GAIN = -.1689-00

ROOTS

REAL PART	IMAGINARY PART
-.2793-00	.0000
-.5900-01	.4446-00
-.5900-01	-.4446-00
.2258-00	.2527-00
.2258-00	-.2527-00
.6245+01	.0000
-.1356+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

148

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 21 SPEED=101.5 FT/SEC, H-DOT=-28.8 FT/SEC, GAMMA=-16.55DEG,
GROSS WEIGHT=15600, SEA LEVEL, DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.6396+02	.1486+01	-.7705+02	-.2426+03	.1532+04	.2516+03
Y	-.1750+01	-.4648+02	-.2906+01	-.1267+04	-.8028+02	.1291+04
Z	-.1412+03	.5764+00	-.2759+03	-.3126+03	-.1629+03	.6844+03
L	-.7410+02	-.4018+02	-.9772+02	-.7984+05	.9203+04	.1573+05
M	.3735+01	-.1764+02	.2924+03	-.6515+04	-.8108+05	.4071+04
N	-.1090+03	.6037+03	-.3069+03	.1300+05	.3333+04	-.3187+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.4915-01	-.3392-03	-.1812-00	-.2575+02	.2754+01	.6931+01
Y	.1108-01	.7717-04	.4090-01	-.1814+01	-.2571+02	.4876+00
Z	.4638-02	-.9223-03	.2021-01	.4849+01	.1977+01	-.1306+01
L	.2790+01	-.1179-02	.1037+02	.2782+04	-.1236+04	-.7470+03
M	.1682+01	.7964-02	.6198+01	.1273+04	.3015+04	-.3427+03
N	-.9203-00	-.1246-02	-.3416+01	-.8972+03	.3587+03	.2500+03

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.4970+05	-.5490+04	.2282+05	-.1251+03	-.1186+05
Y	-.2405+04	.1203+05	.5588+04	.9090+04	.3414-02
Z	-.1323+06	.1126+04	.3030+05	.8397+01	.3383+04
L	-.5487+05	.6268+06	.2574+06	-.6380+05	-.7360+04
M	.3046+06	.2625+06	-.6864+06	-.7929+03	.1661+05
N	-.5244+04	-.1889+06	-.2680+05	-.2681+06	-.7371+03

THE INERTIA TENSOR

$$
\begin{array}{ccc}
.1444+05 & .8157-07 & .1092+05 \\
.8157-07 & .5000+05 & -.2505-07 \\
.1092+05 & -.2505-07 & .5206+05
\end{array}
$$

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.9801+02	.2328-09	.2639+02	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

| .1092+00 | .2615-02 | .3553-02 | .6179-02 | -.2465-01 | .4073-03 |

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.2877-00   PHI .4246-03
AIRCRAFT INERTIAL SPEED= .1015+03

DENOMINATOR CHARACTERISTIC
ROOTS

REAL PART	IMAGINARY PART
-.3726-01	.0000
-.9702+01	.0000
-.2159+01	.0000
-.3073-00	.1027+01
-.3073-00	-.1027+01
-.2697-00	.1980-00
-.2697-00	-.1980-00
.2494-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000
.0000	.0000

NUMERATORS
(NOTE- NUMERATOR ROOTS LESS THAN 1.0E-7 TIMES THE
LARGEST NUMERATOR ROOT ARE NOT INCLUDED IN THE BODE GAIN).

X(1)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .1020+03

BODE GAIN =   .1067+04

ROOTS

REAL PART	IMAGINARY PART
-.3649-01	.0000
-.9727+01	.0000
-.6753-00	.1283+01
-.6753-00	-.1283+01
-.3230-00	.1039+01
-.3230-00	-.1039+01
-.2963-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(2)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .5292+01

BODE GAIN =   -.4169+03

ROOTS

REAL PART	IMAGINARY PART
-.4203-01	.0000
-.3679+02	.0000
-.1234+01	.3119+01
-.1234+01	-.3119+01
.6206-00	.0000
-.1984-00	.3785-00
-.1984-00	-.3785-00
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .2731+03

BODE GAIN =   -.1069+04

ROOTS

REAL PART	IMAGINARY PART
-.3697-01	.0000
-.9807+01	.0000
-.3082-00	.1019+01
-.3082-00	-.1019+01
.1221+01	.0000
-.2733-00	.3470-00
-.2733-00	-.3470-00
-.1022-07	.0000
.0000	.0000
.0000	.0000

151

X(4)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .7252+01

BODE GAIN = -.9891-07

ROOTS

REAL PART	IMAGINARY PART
-.9223-01	.0000
-.9673-01	.0000
-.8616-00	.2474-00
-.8616-00	-.2474-00
-.7642-01	.7820-00
-.7642-01	-.7820-00
.3717-00	.0000
.0000	.0000
.2075-06	.0000
.2819-07	.0000

X(5)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.6235+01

BODE GAIN = -.6839-03

ROOTS

REAL PART	IMAGINARY PART
-.2836-03	.0000
-.1029+02	.0000
-.3121-00	.1028+01
-.3121-00	-.1028+01
-.3691-00	.0000
-.6011-01	.0000
-.3676-01	.0000
-.1613-06	.0000
-.2581-08	.0000
.0000	.0000

152

X(6)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.1616+01

BODE GAIN = -.1612+01

ROOTS

REAL PART	IMAGINARY PART
-.8022-01	.0000
-.7039-00	.3189+01
-.7039-00	-.3189+01
-.2533-00	.3859-00
-.2533-00	-.3859-00
.8776-00	.0000
.1560-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .1547+02

BODE GAIN = .2427+04

ROOTS

REAL PART	IMAGINARY PART
.1241-06	.0000
-.4135-00	.0000
-.6881-01	.0000
-.2758-00	.1030+01
-.2758-00	-.1030+01
-.8347+01	.0000
-.1102+01	.3649+01
-.1102+01	-.3649+01
.0000	.0000
.0000	.0000

153

X(2)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.2413+02

BODE GAIN = .2798+04

ROOTS

REAL PART	IMAGINARY PART
-.1778-00	.1543-00
-.1778-00	-.1543-00
-.8371+02	.0000
-.2631+01	.0000
-.8081-00	.7148-00
-.8081-00	-.7148-00
.2043-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.3144+01

BODE GAIN = -.1170+04

ROOTS

REAL PART	IMAGINARY PART
.1625-06	.0000
-.2287+03	.0000
-.5923+01	.0000
-.2879-00	.1036+01
-.2879-00	-.1036+01
-.1190+00	.2910-00
-.1190+00	-.2910-00
-.6020-01	.0000
.0000	.0000
.0000	.0000

154

X(4)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.7327+02

BODE GAIN = .1684+02

ROOTS

REAL PART	IMAGINARY PART
-.9170-01	.0000
-.2581-00	.2034-00
-.2581-00	-.2034-00
.2451-00	.0000
-.2208+01	.0000
-.2620-00	.1002+01
-.2620-00	-.1002+01
.1254-06	.0000
.3514-07	.0000
.0000	.0000

X(5)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.7720+01

BODE GAIN = .2416-01

ROOTS

REAL PART	IMAGINARY PART
.5265-02	.0000
-.5542+01	.0000
-.2890-00	.1027+01
-.2890-00	-.1027+01
-.6264-00	.0000
-.7829-01	.0000
-.4810-01	.0000
-.2235-07	.0000
.1115-07	.0000
.0000	.0000

155

X(6)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .2030+02

BODE GAIN = .5691+02

ROOTS

REAL PART	IMAGINARY PART
-.2453-00	.1912-00
-.2453-00	-.1912-00
.2589-00	.0000
-.2441+01	.0000
-.6747-00	.1036+01
-.6747-00	-.1036+01
.7508-00	.0000
-.8382-08	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.4522+02

BODE GAIN = -.3905+04

ROOTS

REAL PART	IMAGINARY PART
-.3239-01	.0000
-.4065-00	.0000
-.9884+01	.0000
-.2648-00	.3827+01
-.2648-00	-.3827+01
-.3133-00	.1015+01
-.3133-00	-.1015+01
-.2523-06	.0000
.5538-09	.0000
.1224-07	.0000

155

X(2)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.1214+02

BODE GAIN = .1944+04

ROOTS

REAL PART	IMAGINARY PART
-.1032+00	.0000
-.6633+02	.0000
-.2820-02	.2729-00
-.2820-02	-.2729-00
-.1997+01	.1949+01
-.1997+01	-.1949+01
.1010+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.6282+02

BODE GAIN = .2291+04

ROOTS

REAL PART	IMAGINARY PART
-.3382-01	.0000
.2178+02	.0000
-.1169+00	.3043-00
-.1169+00	-.3043-00
-.1032+02	.0000
-.3088-00	.1017+01
-.3088-00	-.1017+01
-.2568-06	.0000
.0000	.0000
.0000	.0000

157

X(4)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3138+02

BODE GAIN = .9180+01

ROOTS

REAL PART	IMAGINARY PART
-.9188-01	.0000
-.3735-00	.5279-01
-.3735-00	-.5279-01
.2773-00	.0000
-.1083+00	.1098+01
-.1083+00	-.1098+01
-.1660+01	.0000
.6694-08	.1166-06
.6694-08	-.1166-06
.1863-07	.0000

X(5)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .1369+02

BODE GAIN = .1317-01

ROOTS

REAL PART	IMAGINARY PART
-.2096-02	.0000
-.1079+02	.0000
-.3120-00	.1021+01
-.3120-00	-.1021+01
-.6195-00	.0000
-.4948-01	.0000
-.3048-01	.0000
-.9872-07	.0000
.0000	.0000
-.2235-07	.0000

158

X(6)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN=   .7774+01

BODE GAIN =   .3103+02

ROOTS

REAL PART	IMAGINARY PART
-.2236-00	.0000
.2180-00	.0000
-.1773-00	.3910-00
-.1773-00	-.3910-00
-.1613+01	.1873+01
-.1613+01	-.1873+01
.1819+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN=   .3106-00

BODE GAIN = -.1556+03

ROOTS

REAL PART	IMAGINARY PART
-.1153-07	.0000
-.8534+01	.2767+01
-.8534+01	-.2767+01
-.3078+01	.0000
-.4373-00	.0000
.2302+01	.0000
-.5130-01	.2183-00
-.5130-01	-.2183-00
.0000	.0000
.0000	.0000

159

X(2)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.1876+02

BODE GAIN = .8413+02

ROOTS

REAL PART	IMAGINARY PART
-.7114-02	.0000
-.2794+02	.0000
-.9170+01	.0000
-.2153+01	.0000
-.2736-00	.1965-00
-.2736-00	-.1965-00
.2522-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.2722-01

BODE GAIN = .6660+02

ROOTS

REAL PART	IMAGINARY PART
-.3439-08	.0000
.2272+03	.0000
-.6157-01	.3661-00
-.6157-01	-.3661-00
-.8250-01	.1636-00
-.8250-01	-.1636-00
-.1737+02	.0000
-.3357+01	.0000
.0000	.0000
.0000	.0000

160

X(4)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .3824-00

BODE GAIN = -.2331+01

ROOTS

REAL PART	IMAGINARY PART
-.9560-01	.0000
-.3484+02	.0000
-.2178+01	.0000
-.7351-00	.0000
-.2747-00	.1991-00
-.2747-00	-.1991-00
.2485-00	.0000
-.4657-09	.0000
.0000	.0000
.0000	.0000

X(5)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.9865-02

BODE GAIN = -.3346-02

ROOTS

REAL PART	IMAGINARY PART
-.5535-08	.0000
.6499+02	.0000
.1107-01	.0000
-.4785-01	.0000
-.6831-01	.2444-00
-.6831-01	-.2444-00
-.4252+01	.^000
-.8999-00	.0000
.1863-08	.0000
.0000	.0000

X(6)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .5087+01

BODE GAIN = -.7879+01

ROOTS

REAL PART	IMAGINARY PART
-.2103-01	.2607-00
-.2103-01	-.2607-00
-.2741-00	.1969-00
-.2741-00	-.1969-00
-.9238+01	.0000
-.2152+01	.0000
.2502-00	.0000
.1368-08	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .2443+02

BODE GAIN = .9705+02

ROOTS

REAL PART	IMAGINARY PART
-.3009-06	.0000
-.9715+01	.0000
-.2649-00	.2974-00
-.2649-00	-.2974-00
-.3128-01	.0000
-.3084-00	.1031+01
-.3084-00	-.1031+01
-.1781+01	.0000
.0000	.0000
.0000	.0000

162

X(2)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .1408-01

BODE GAIN = -.5115+02

ROOTS

REAL PART	IMAGINARY PART
-.5671-01	.1652-00
-.5671-01	-.1652-00
-.2327-00	.0000
-.1129+04	.0000
-.1547+01	.1867+01
-.1547+01	-.1867+01
.1915+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.6975+01

BODE GAIN = -.5458+02

ROOTS

REAL PART	IMAGINARY PART
-.3245-01	.0000
-.8564+01	.1856+01
-.8564+01	-.1856+01
-.3083-00	.1022+01
-.3083-00	-.1022+01
-.1905-00	.1808-00
-.1905-00	-.1808-00
-.1689-06	.0000
.1496-07	.0000
-.3725-08	.0000

163

X(4)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .8473-00

BODE GAIN = -.2686-00

ROOTS

REAL PART	IMAGINARY PART
-.9215-01	.0000
-.3194-00	.2083-00
-.3194-00	-.2083-00
.2921-00	.0000
-.1493-00	.1068+01
-.1493-00	-.1068+01
-.1744+01	.0000
.8005-08	.0000
-.6713-07	.3571-07
-.6713-07	-.3571-07

X(5)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.3293-00

BODE GAIN = -.3860-03

ROOTS

REAL PART	IMAGINARY PART
-.4148-03	.0000
-.1094+02	.0000
-.3109-00	.1021+01
-.3109-00	-.1021+01
-.4692-00	.0000
-.3288-00	.0000
-.3680-01	.0000
.3556-09	.0000
.2679-07	.3855-07
.2679-07	-.3855-07

X(6)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.1813-00

BODE GAIN = -.9079-00

ROOTS

REAL PART	IMAGINARY PART
-.3919-00	.0000
-.209%-00	.3000-00
-.2091-00	-.3000-00
.2098-00	.0000
.2842+01	.0000
-.1203+01	.1602+01
-.1203+01	-.1602+01
.0000	.0000
.0000	.0000
.0000	.0000

LOCKHEED AH56A HELICOPTER   JUNE 10 1970   MOSTAB-B DERIVATIVES
CASE 22 SPEED=169.0 FT/SEC.   W-DOT=-28.8 FT/SEC.   GAMMA= -9.81DEG.
GROSS WEIGHT=15600.   SEA LEVEL. DYNAMIC TIP LOSS (YES)

STABILITY DERIVATIVE MATRICES-

	U	V	W	P	Q	R
X	-.4236+02	.1285+01	-.3647+02	-.3224+03	.1190+04	.1079+03
Y	-.4353-00	-.6710+02	-.5054+01	-.8979+03	-.6785+02	.1414+04
Z	-.1013+03	.2195+01	-.4280+03	-.9451+03	-.6615+03	.6440+03
L	-.4454+02	-.9339+02	-.4814+02	-.8129+05	.6915+04	.6343+04
M	-.8798+02	-.6778+01	-.1864+03	-.4231+04	-.9865+05	.2048+04
N	-.4110+02	.7502+03	-.2576+03	.1569+04	.8030+04	-.4021+05

	U DOT	V DOT	W DOT	P DOT	Q DOT	R DOT
X	-.2110-01	-.3853-03	-.2485-00	-.1929+02	.1748+01	.1600+01
Y	.2227-02	-.4448-03	.3222-01	-.7042-00	-.1650+02	.5432-01
Z	-.4989-02	-.3099-02	-.2715-01	-.2503+01	.5844+01	.1937-00
L	.1515+01	-.2106-01	.1847+02	.3037+04	-.1170+04	-.2522+03
M	.8374-00	.7252-02	.9825+01	.1247+04	.3059+04	-.1043+03
N	-.2441-00	-.4044-03	-.2934+01	-.4584+03	.1204+03	.4670+02

	C(1)	C(2)	C(3)	C(4)	C(5)
X	-.3424+05	-.3967+04	.1974+05	-.3372+03	-.1651+05
Y	-.3570+04	.9066+04	.4311+04	.1258+05	.1404-01
Z	-.1675+06	-.3991+03	.6727+05	.1620+02	.1518+04
L	-.7268+05	.6393+06	.2329+06	-.2067+05	-.1608+05
M	.5710+06	.2484+06	-.7570+06	-.1706+03	.1902+05
N	-.4763+05	-.7417+05	.3608+05	-.3820+06	-.1908+03

THE INERTIA TENSOR

.1180+05	-.8421-06	.3599+04
-.8421-06	.5000+05	.7933-07
.3599+04	.7933-07	.5470+05

TRIMMED VELOCITIES WITH RESPECT TO OVERALL VEHICLE REFERENCE AXES-

U	V	W	P	Q	R
.1684+03	-.3725-08	.1403+02	-.0000	.0000	-.0000

TRIMMED ITERATION COLUMN VECTOR, TE-

.1073+00   .5612-02   -.9721-03   .1199-01   -.5221-01   -.5821-02

STABILITY AXIS SYSTEM EULER ANGLES-   THETA= -.1353-00   PHI -.5867-02
AIRCRAFT INERTIAL SPEED= .1690+03

DENOMINATOR CHARACTERISTIC
ROOTS

REAL PART	IMAGINARY PART
-.2494-01	.0000
-.9564+01	.0000
-.4314-00	.1492+01
-.4314-00	-.1492+01
.7332-01	.0000
-.1502+01	.5799-00
-.1502+01	-.5799-00
-.1291-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000
.0000	.0000

NUMERATORS
(NOTE- NUMERATOR ROOTS LESS THAN 1.0E-7 TIMES THE
LARGEST NUMERATOR ROOT ARE NOT INCLUDED IN THE BODE GAIN).

X(1)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .7003+02

BODE GAIN =   .1394+05

ROOTS

REAL PART	IMAGINARY PART
-.2176-01	.0000
-.9566+01	.0000
-.7348-00	.2747+01
-.7348-00	-.2747+01
-.4348-00	.1483+01
-.4348-00	-.1483+01
-.6990-00	.0000
.1286-11	.0000
.1166-06	.0000
.0000	.0000

167

X(2)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .7779+01

BODE GAIN =   -.3016+04

ROOTS

REAL PART	IMAGINARY PART
-.9897-01	.0000
.1742-01	.2117-00
.1742-01	-.2117-00
-.1490+02	.0000
.1680-00	.4065+01
.1680-00	-.4065+01
.4974+01	.0000
.5453-07	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .3455+03

BODE GAIN =   .2191-01

ROOTS

REAL PART	IMAGINARY PART
-.5592-05	.0000
-.9626+01	.0000
-.2258-01	.0000
-.8670-01	.2647-00
-.8670-01	-.2647-00
.3940+01	.0000
-.4292-00	.1467+01
-.4292-00	-.1467+01
.0000	.0000
.0000	.0000

X(4)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= .1059+02

BODE GAIN = .1411-04

ROOTS

REAL PART	IMAGINARY PART
-.2529-01	.0000
-.1080+00	.1445+01
-.1080+00	-.1445+01
.2610-00	.0000
-.9903-00	.1301+01
-.9903-00	-.1301+01
-.2203-00	.0000
.0000	.0000
-.2215-05	.0000
.6519-08	.0000

X(5)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN= -.1181+02

BODE GAIN = .2745-00

ROOTS

REAL PART	IMAGINARY PART
.6200-02	.0000
-.9959+01	.0000
-.4320-00	.1489+01
-.4320-00	-.1489+01
-.1016+01	.0000
-.6507-01	.0000
-.3345-01	.0000
-.3129-06	.0000
.4191-07	.0000
.0000	.0000

X(6)-TO-C(1) NUMERATOR

ROOT LOCUS GAIN=   .401*-01

BODE GAIN =   -.4679+02

ROOTS

REAL PART	IMAGINARY PART
-.2234-00	.0000
.1879-00	.0000
-.1505-00	.4475-00
-.1505-00	-.4475-00
-.1638+03	.0000
.1928-00	.3271+01
.1928-00	-.3271+01
-.9313-09	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN=   .1117+02

BODE GAIN =   .7353+04

ROOTS

REAL PART	IMAGINARY PART
-.5228-07	.0000
-.6259-00	.0000
-.3443-01	.0000
-.4095-00	.1488+01
-.4095-00	-.1488+01
-.9518+01	.0000
-.1457+01	.4112+01
-.1457+01	-.4112+01
.0000	.0000
.0000	.0000

170

X(2)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.1835+02

BODE GAIN = .2120+04

ROOTS

REAL PART	IMAGINARY PART
.4965-01	.0000
-.1470-00	.0000
-.2472-00	.0000
-.6174+02	.0000
-.3885+01	.0000
-.1213+01	.1516+01
-.1213+01	-.1516+01
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= .1126+01

BODE GAIN = -.1757+04

ROOTS

REAL PART	IMAGINARY PART
.1060-05	.0000
.9484+03	.0000
-.3262-01	.0000
-.6732-01	.2008-00
-.6732-01	-.2008-00
-.6586+01	.0000
-.4191-00	.1495+01
-.4191-00	-.1495+01
.0000	.0000
.0000	.0000

171

X(4)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.7501+02

BODE GAIN = -.1349-04

ROOTS

REAL PART	IMAGINARY PART
-.2528-01	.0000
-.4278-00	.1467+01
-.4278-00	-.1467+01
-.1523+01	.4733-00
-.1523+01	-.4733-00
-.1202+00	.0000
.5913-01	.0000
-.2381-05	.0000
.2874-08	.0000
-.4657-08	.0000

X(5)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN= -.7299+01

BODE GAIN = -.2442-00

ROOTS

REAL PART	IMAGINARY PART
-.9861-02	.1879-01
-.9861-02	-.1879-01
-.5995+01	.0000
-.4223-00	.1491+01
-.4223-00	-.1491+01
-.9192-00	.0000
-.7929-01	.0000
-.2490-07	.0000
.2118-07	.0000
.0000	.0000

172

X(6)-TO-C(2) NUMERATOR

ROOT LOCUS GAIN=   .6910+01

BODE GAIN =   .4162+02

ROOTS

REAL PART	IMAGINARY PART
.5994-01	.0000
-.1198+00	.0000
-.8750-00	.0000
-.2851+01	.0000
-.9947-00	.1763+01
-.9947-00	-.1763+01
.1159+01	.0000
.1071-07	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.3943+02

BODE GAIN = -.1647+05

ROOTS

REAL PART	IMAGINARY PART
-.2088-01	.0000
-.6537-00	.0000
-.4325-00	.1482+01
-.4325-00	-.1482+01
-.9569+01	.0000
-.4701-00	.4328+01
-.4701-00	-.4328+01
-.1495-06	.0000
.0000	.0000
.0000	.0000

173

X(2)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.9386+01

BODE GAIN = .4410+04

ROOTS

REAL PART	IMAGINARY PART
-.1064+00	.0000
.6004-01	.1974-00
.6004-01	-.1974-00
-.3251+02	.0000
-.2474+01	.4135+01
-.2474+01	-.4135+01
.1942+01	.0000
-.9313-09	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.1385+03

BODE GAIN = .4350+04

ROOTS

REAL PART	IMAGINARY PART
-.2171-01	.0000
.1732+02	.0000
-.6203-01	.2138-00
-.6203-01	-.2138-00
-.9946+01	.0000
-.4297-00	.1486+01
-.4297-00	-.1486+01
.0000	.0000
.0000	.0000
.0000	.0000

174

X(4)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= -.2961+02

BODE GAIN = -.4617-04

ROOTS

REAL PART	IMAGINARY PART
-.2528-01	.0000
-.2853-00	.1505+01
-.2853-00	-.1505+01
.1534-00	.0000
-.1256+01	.1114+01
-.1256+01	-.1114+01
-.1835-00	.0000
-.4682-05	.0000
-.3568-08	.0000
.3725-08	.0000

X(5)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .1531+02

BODE GAIN = -.4250-00

ROOTS

REAL PART	IMAGINARY PART
.7550-02	.0000
-.1032+02	.0000
-.4319-00	.1488+01
-.4319-00	-.1488+01
-.9306-00	.0000
-.6215-01	.0000
-.3626-01	.0000
.7916-08	.5703-07
.7916-08	-.5703-07
.0000	.0000

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X(6)-TO-C(3) NUMERATOR

ROOT LOCUS GAIN= .1580+01

BODE GAIN = .7244+02

ROOTS

REAL PART	IMAGINARY PART
.1360-00	.0000
-.1838-00	.0000
-.2052-00	.5379-00
-.2052-00	-.5379-00
-.1779+01	.3736+01
-.1779+01	-.3736+01
.4565+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= .7483-00

BODE GAIN = -.3027+03

ROOTS

REAL PART	IMAGINARY PART
-.2371-06	.0000
-.9543+01	.0000
-.6563-00	.0000
-.7273-01	.1600-00
-.7273-01	-.1600-00
-.3460+01	.1419+01
-.3460+01	-.1419+01
.2111+01	.0000
.0000	.0000
.0000	.0000

X(2)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.2596+02

BODE GAIN = .1949+03

ROOTS

REAL PART	IMAGINARY PART
-.9736-02	.0000
-.4585+02	.0000
-.9450+01	.0000
-.1505+01	.5970-00
-.1505+01	-.5970-00
-.1289-00	.0000
.7437-01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.2706-01

BODE GAIN = .6863+02

ROOTS

REAL PART	IMAGINARY PART
-.7366-01	.7693-01
-.7366-01	-.7693-01
.2085+03	.0000
.1388-00	.3519-00
.1388-00	-.3519-00
-.2567+02	.0000
-.4126+01	.0000
.0000	.0000
.0000	.0000
.0000	.0000

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X(4)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.7325-00

BODE GAIN = -.8197-00

ROOTS

REAL PART	IMAGINARY PART
.4600-06	.0000
.1216+02	.0000
.7098-01	.0000
.0000	.0000
-.2300+01	.0000
-.1424+01	.6264-00
-.1424+01	-.6264-00
-.1302-00	.0000
-.2528-01	.0000
.1956-07	.0000

X(5)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN= -.3147-01

BODE GAIN = .3532-01

ROOTS

REAL PART	IMAGINARY PART
-.1644-01	.6376-01
-.1644-01	-.6376-01
.1949+02	.0000
-.1799-00	.2016-00
-.1799-00	-.2016-00
-.4904+01	.0000
-.5237-00	.0000
.2401-07	.0000
-.6462-06	.0000
.3440-06	.0000

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X(6)-TO-C(4) NUMERATOR

ROOT LOCUS GAIN=   .7044+01

BODE GAIN =   -.6020+01

ROOTS

REAL PART	IMAGINARY PART
.7155-01	.0000
-.1301-00	.0000
-.9418+01	.0000
-.1505+01	.5971-00
-.1505+01	-.5971-00
-.3938-01	.2258-00
-.3938-01	-.2258-00
.5093-10	.0000
.0000	.0000
.0000	.0000

X(1)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN=   .3400+02

BODE GAIN =   .3724+03

ROOTS

REAL PART	IMAGINARY PART
-.1819-01	.0000
-.9565+01	.0000
-.4327-00	.1494+01
-.4327-00	-.1494+01
-.1402+01	.8359-00
-.1402+01	-.8359-00
-.1379-00	.0000
-.2615-11	.0000
.0000	.0000
.0000	.0000

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X(2)-TO-C(5) NUMERATOP

ROOT LOCUS GAIN= .9109-02

BODE GAIN = -.1593+03

ROOTS

REAL PART	IMAGINARY PART
-.1272-00	.0000
-.8051-02	.2694-00
-.8051-02	-.2694-00
-.2202+04	.0000
-.3023+01	.2958+01
-.3023+01	-.2958+01
.6787-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

X(3)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.3148+01

BODE GAIN = -.9808+02

ROOTS

REAL PART	IMAGINARY PART
-.1919-01	.0000
-.2171+02	.0000
-.1194+02	.0000
-.4312-00	.1486+01
-.4312-00	-.1486+01
-.2416-00	.0000
-.1529-00	.0000
.0000	.0000
.0000	.0000
.0000	.0000

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X(4)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= .1943+01

BODE GAIN = -.1641-04

ROOTS

REAL PART	IMAGINARY PART
-.2532-01	.0000
-.3716-00	.1475+01
-.3716-00	-.1475+01
-.1387+01	.8440-00
-.1387+01	-.8440-00
.1343-00	.0000
-.1309-00	.0000
.0000	.0000
.4392-04	.0000
-.4373-08	.0000

X(5)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.3533-00

BODE GAIN = .1608-01

ROOTS

REAL PART	IMAGINARY PART
.6332-02	.0000
-.1161+02	.0000
-.4332-00	.1487+01
-.4332-00	-.1487+01
-.9466-00	.0000
-.1246+00	.0000
-.3089-01	.0000
.5539-07	.0000
-.1535-07	.0000
.0000	.0000

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X(6)-TO-C(5) NUMERATOR

ROOT LOCUS GAIN= -.1416-00

BODE GAIN = -.2741+01

ROOTS

REAL PART	IMAGINARY PART
.8924-08	.0000
-.4440-00	.6432-00
-.4440-00	-.6432-00
-.1310-00	.0000
.1236+00	.0000
-.2042+01	.2760+01
-.2042+01	-.2760+01
.2346+01	.0000
.0000	.0000
.0000	.0000

VIII. LOW-ALTITUDE TU~~~~.. REPRESENTATION

INTRODUCTION

This Part summarizes some of the recent observations of ___ the atmospheric environment pertinent to V/STOL aircraft. A number of formulas for wind-shear and turbulence parameters have been gleaned from the references and are presented here. In many cases, however, the data were obtained under special environmental or climatic conditions. Estimating the influence of temperature, wind speed and direction, seasonal and geographic variations, elevation, stability, etc., on the various parameters is presently a formidable task. A massive program of data collection and analyses will be required before any degree of confidence can be assigned to the various meteorological descripters. Wind shears can reverse direction (see Reference 3) - a phenomenon which cannot be explained by present theoretical or empirical relationships. Consequently, in using the relationships herein, one should expect results that are, at best, qualitatively significant.

The principal conclusion formed after surveying the data presented here is that satisfactory data are conspicuous by their absence, and that published empirical relationships that have been used to fit the limited available data are in forms which are inconvenient for flight control system analysis.

WIND PROFILES NEAR THE GROUND

Much of the recent progress in understanding the wind (and temperature) distribution is due to the Monin-Obukhov similarity theory (Reference 1). This theory states that there exists, near the ground, a velocity U^*, a length L, and a temperature T^* that are essentially invariant with height. When the principal variables are divided by these quantities, a series of nondimensional quantities results that is of general validity in the boundary layer. The variables are defined as follows:

   a. Friction Velocity $\quad U^* = \sqrt{\tau/\rho}$ independent of Z

   b. Scaling Length $\quad L = U^{*3} c_p \rho T/kgH$, $k \approx .4$

   c. Scaling Temperature $\quad T^* = -H/kU^* c_p \rho$

From this theory a number of conclusions are reached on the basis of dimensional analysis. While many of the results are realistic, others are somewhat misleading or incorrect.

1. Richardson Number

The Richardson number represents the ratio of buoyant force to the shear and, as such, is a measure of the local stability of the atmosphere. The stability regions, in turn, have a significant effect on the wind profiles and statistical properties. The gradient Richardson number R_1, which is easily measured, is usually used in preference to the traditional Richardson number R_t. It is defined as

$$R_1 = \frac{g}{\theta} \frac{\partial \theta}{\partial Z} \Big/ \left(\frac{\partial U}{\partial r_3}\right)^2$$

where r_3 is orthogonal to the wind direction and for horizontal winds is parallel with Z. The potential temperature, θ, is defined by

$$\frac{1}{\theta}\frac{\partial \theta}{\partial Z} = \frac{1}{T}\frac{\partial T}{\partial Z} - \frac{R}{c_p}\frac{1}{p}\frac{\partial p}{\partial Z}$$

such that $T/\theta = \text{Const } (p)^{R/c}p$. Linearized theory states that the air is unstable and turbulent if $R_1 < 0$, stable if $R_1 > \frac{1}{4}$, and possibly unstable if $0 < R_1 < \frac{1}{4}$.

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For V/STOL approach conditions, the Richardson number can be assumed negative and negligibly small. This corresponds to instability with strong winds overhead, the two conditions which produce the greatest turbulence.

2. Velocity Profiles According to Panofsky

For Neutral Air

$$V = \frac{U^*}{k} \ln \frac{Z + Z_o}{Z_o} \qquad \frac{\partial V}{\partial Z} = \frac{U^*}{K(Z + Z_o)}$$

Near Neutral Conditions:

For small Z/L, $Z \gg Z_o$

$$V = \frac{U^*}{k} \left(\ln \frac{Z}{Z_c} + \beta \frac{Z}{L} \right) = \frac{U^*}{k} \left(\ln \frac{Z}{Z_o} + \beta' \frac{Z}{L'} \right)$$

$$\theta - \theta_o = T^* \left(\ln \frac{Z}{Z_o} + \beta' \frac{Z}{L'} \right)$$

$$R_i = \frac{Z/L'}{1 + \beta' \ Z/L'}$$

where

$$L' = \frac{K_h}{K_m} L \qquad \beta' \cong 4.5$$

$$K_m = U^{*2} / \frac{\partial V}{\partial Z} \quad \text{(Eddy viscosity)}$$

$$K_h = - H/C_p \rho \ \frac{\partial \theta}{\partial Z} \quad \text{(Eddy conductivity)}$$

Free Convection:

$$\frac{\partial V}{\partial Z} = \frac{K_h}{K_m} U^{*2} \left(\frac{gH}{\rho C_p T} \right)^{-\frac{1}{3}} Z^{-\frac{4}{3}}$$

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Unstable Air (Neutral Equilibrium - Free Convection):

$$V = \frac{U^*}{k}\left(\ln\frac{Z}{Z_o} - \psi\ \frac{Z}{L'}\right)$$

where ψ is determined from R_1 by graphs (Lumley and Panofsky, page 113).

Stable Air:

$$V = \frac{U^*}{k}\ \ln\frac{Z}{Z_o} + \beta'\frac{Z}{L'}\quad \frac{Z}{L'} = \frac{R_1}{1 - \beta'R_1}\quad \frac{Z}{L'} \leq .3\quad 4.5 < \beta' < 7$$
$$R_1 \sim .1$$

The wind profile may be complicated above $Z/L' > .3$ (See Reference 1, page 118)

3. Calculation According to Skalton
Panofsky's formula,

$$U\,(Z) = \frac{U^*}{k}\ \ln\,(Z/Z_o) - \psi$$

is valid for all thermal stability conditions for the first few meters of the atmosphere. One must choose a reference altitude Z_1, the velocity $U\,(Z_1)$, a roughness length Z_o, and the Richardson number R_1 at that altitude. After calculating U^* and L' (via graphs), they are assumed constant with altitude.

For neutral air - the condition which produces the greatest turbulence, $R_1 = 0$, and

$$U\,(Z) = \frac{U^*}{k}\ \ln\,(Z/Z_o)$$

The roughness length, Z_o, will be assumed to vary from .03 to 5 meters. The probability distribution at 9.1 m altitude with a roughness length of .03 m is assumed to be that obtained by drawing a straight line on normal probability paper between 4 m/s at .5 likelihood and 12 m/s at .01 likelihood (Reference 5). At any other altitude, $Z < 100$ m,

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$$U(Z) = U(9\ 1)\left(\frac{Z}{9.1}\right)^{.12}$$

$$\left(\text{Expansion of } U(Z) = \frac{U^*}{k}\ln\left(Z/Z_o\right)\right)$$

where the exponent can vary between .12 for smooth terrain and .38 for rough terrain. Hence,

$$\text{Prob}\left\{U(Z) < \alpha\right\} = \text{Prob}\left\{U(9.1) < \alpha\left(\frac{9.1}{Z}\right)^{.12}\right\}$$

For the lowest few meters of the atmosphere where the above expansion is invalid, $p = 1/\ln(Z/Z_o)$. This is approximated by

$$p(Z_o) = .9/(4 - \ln Z_o)$$

and the wind profile is

$$U(Z) = U(Z_1)\left(\frac{Z}{Z_1}\right)^{p(Z_o)}$$

The wind probability distribution at 100 m will be assumed to be the same everywhere. If we take the mean airspeed at 9.1 meters to be $\bar{U} = 4$ m/sec for smooth terrain, the mean airspeed at 100 meters is

$$\bar{U}(100\text{ m}) = \left(\frac{100}{9.1}\right)^{.12} \times 4 = 5.33 \text{ m/sec}$$

Assuming that the 100 meter value applies for both smooth and rough terrain, we obtain for rough terrain at 9.1 meters

$$\bar{U}(9.1\text{ m})_{\text{Rough}} = \left(\frac{9.1}{100}\right)^{.38} \times 5.33 = 2.15 \text{ m/sec}$$

Below 9.1 meters,

$$U(Z) = U(9.1)\left(\frac{Z}{9.1}\right)^{\frac{.9}{4 - \ln Z_o}}$$

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4. **Measured Variations Between Rural and Urban Areas - Bowne**
The principal results of Reference 3 are:

a. The mean wind speed was reduced at all elevations in the city by the increased roughness.

b. At neutral stability ($R_i \sim 0$), the maximum value of U* is the same in city and country.

c. The city influence is more noticeable for stable rural conditions; U* is then greater in the city.

d. City stability is always less than rural stability.

e. Reynolds stress varies significantly with height in both city and country.

f. All $\sigma_u/U*$, $\sigma_v/U*$, and $\sigma_w/U*$ measurements are comparable to those obtained elsewhere.

5. Comments
Test data (e.g., Bowne) show considerable scatter; consequently, results are qualitative at best. Slight changes in wind direction or in temperature can have profound effects on measured results. For example, the wind shear can be constant with altitude. At higher temperatures, the Bowne data show reversals or highly variable wind profiles.

TURBULENT FLUCTUATIONS
The relationship between the longitudinal, lateral, and vertical spectra and the elevation, stability, and ground roughness is not accurately known at present. Available data is limited and the similarity theory is useful in only a limited sense.

1. Turbulence Scales
Horizontal scales increase linearly with altitude. No information exists on the effect of wind speed except for very low speeds where the scale is unaffected. Ratios of the variances are approximately

$$\sigma_u/\sigma_v/\sigma_w/U* \approx 2.8/2.0/1.3/1.0$$

These values are chosen by Skelton together with the assumption that the covariances E(UV) and E(VW) are zero. Since $U*^2$ is the negative of E(UW) (see Reference 2, page 16), the correlation matrix can be given approximately as

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$$E\left\{\begin{bmatrix} U \\ V \\ W \end{bmatrix}\{U\ V\ W\}\right\} = .4\ p(Z_o)\ U^2(Z)\begin{bmatrix} 7.8 & 0 & -1 \\ 0 & 4 & 0 \\ -1 & 0 & 1.7 \end{bmatrix}$$

2. Variance of Vertical Velocity
From dimensional analysis,

$$\sigma_w = \frac{A\ k\ V\ h'(Z/L')}{\ln Z/Z_o - \psi(Z/L')}$$

where A and h' are to be determined, preferably from data. In neutrally stable air, the expression

$$\sigma_w = \frac{.4\ A\ V}{\ln Z/Z_o} \quad \text{yields } A \approx 1.05 \text{ (experiment)}$$

In unstable air, σ_w increases slowly with increasing height; in stable air, it decreases upward.

3. Variance of Lateral Velocity
From test results,

$$\sigma_v = .03\ V^{3/2} \text{ or } .07\ V^{3/2} \text{ at 11 meters, stable air}$$

The standard deviation increases with increasing wind speed at constant stability. It is much larger in unstable air. Vertical variation and surface roughness are of little influence. Data in unstable air show enormous variability.

4. Variance of Longitudinal Velocity
The properties of longitudinal gustiness are indeterminate, in general. It is assumed that

$$\sigma_u = CU^*$$

where C is independent of height but varies with terrain. With the approximation $C \approx 2.5$,

$$\sigma_u = \frac{VV}{\ln Z/Z_o} \quad \text{(near neutral air)}$$

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5. Spectra

Vertical Velocity

The scale increases with height, but the spectrum is independent of height up to a few hundred meters. A decrease in stability and Richardson number shifts the spectrum to lower frequencies. A suggested spectral shape is

$$nS_w(n) = \sigma_w^2 \frac{f/f_{max}}{\left(1 + f/f_{max}\right)^2}$$

Lateral Velocity

The spectrum is independent of height, at least under neutral and unstable conditions. Increasing instability greatly increases the low-frequency portion of the spectrum, but has no effect on the high-frequency portions. The high-frequency portions are sensitive to roughness and wind speed. A number of spectra are shown for varying conditions in Reference 1.

Longitudinal Velocity

Low frequencies are affected by stability somewhat more than high frequencies; the low-frequency portions increase with decreasing stability. The scale of longitudinal velocities is not proportional to height. One approximation to measured spectra (at 10 meters elevation) is

$$nS_u(n) = 4.0 \, U*^2 \frac{\left(\frac{1200 \cdot n}{V}\right)^2}{\left(1 + \left(\frac{1200 \, n}{V}\right)^2\right)^{4/3}}$$

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A number of spectral plots are illustrated on pages 168 - 183 of Reference 1. Two of these are reproduced below:
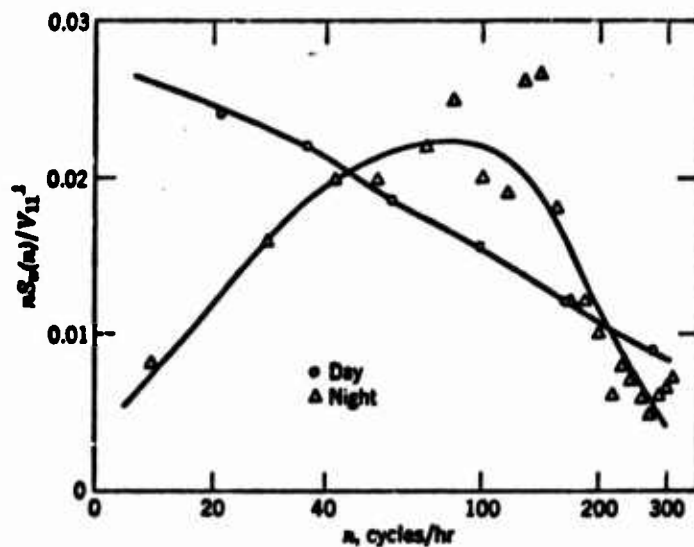

Figure 1. Spectrum of Longitudinal Velocity at 91 m at Brookhaven, Divided by Square of Wind Speed at 11 m. (According to Panofsky and Deland, 1959)
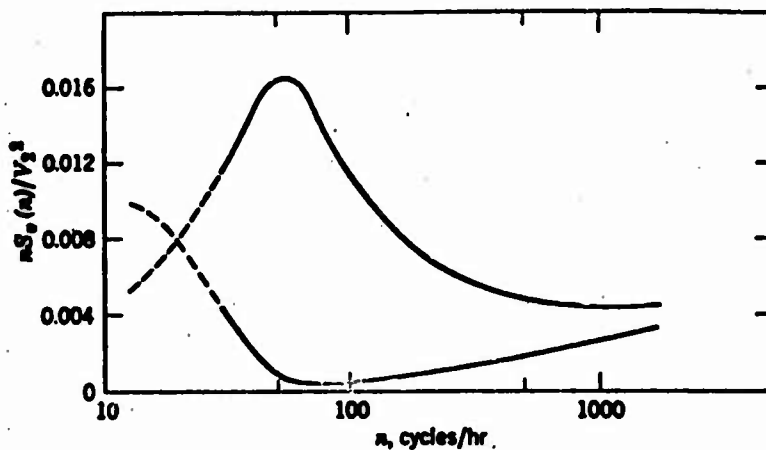

Figure 2. Typical Spectra of Lateral Velocity at O'Neill, Divided by Square of Wind Speed at 2 m. Upper curve, daytime; lower curve, night with gradual fluctuations of wind direction.

6. Gaps in Knowledge

Gust intensities depend on thermal stability, roughness and the mean wind. Statistical data on only the latter are available.

The effects of altitude on probability distributions of mean winds and wind shears are not known, and one cannot deduce gust intensities and severity.

The form of spectra (and cospectra) in other than the down-wind direction and their dependence upon stability, wind speed and wind shear are not known.

It is difficult to determine the validity of the various models for high-wind-speed and/or high-turbulence-intensity conditions.

7. Measured Variations Between Rural and Urban Areas - Bowne

a. The average turbulence intensity was higher in the city than in the rural area, but usually decreased more rapidly with height.

b. Slopes for the high-frequency portion of the three component spectra were very close to the theoretical - 5/3 prediction.

c. The lateral and longitudinal spectra, V and U, were not too different in the two regimes.

CONCLUSIONS

1. The available data are limited in quality and are presented in forms which are intended for ease of correlation with various meteorological theories. Unfortunately these forms are inconvenient for aircraft flight control analysis, where one would prefer power spectra expressed as factorable functions of the frequency variable, plus simple wind-shear descriptions.

2. Extreme variability of wind-shear profiles is common, and profile reversals should be included in test conditions for flight control design criteria.

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